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# Five Methods of Serial Rote Learning:

## A Comparative Study

BY
LOIS ADAMS, PH.D.

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The writer wishes to express her gratitude to Miss Gladys Tallman for assistance in securing subjects for this study and to Miss Beatha Spafford, Principal of Public School 169, for permission to carry on the experimentation in her school.

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# CHAPTER I

## 1. INTRODUCTION[1]

When one is first given the problem of learning a new task calling for a definite or prescribed order, the question naturally arises as to what is the most efficient method. There are usually many ways of learning a given task. The selection of a method depends upon the learner's intelligence, training, interest and special aptitude. It also depends upon incentive and conditions prevailing at the time. To compare methods of learning, conditions must be made fairly constant throughout the tests of such methods.

When errors occur in learning tests one can deal with them in various ways. For instance after making an error the learner can:

I. At once start over again without correcting the error.
II. Go back one step before correcting the error.
III. Proceed without correcting the error.
IV. At once stop and correct the error before going on with the learning.
V. Deliberately repeat the mistake to emphasize the error so that it may be avoided in the future.

All of these techniques have been tested under various conditions, some experimenters reporting one method superior, and others another method. Our present task is to compare all five methods when employed on the same material to discover which of the five is the most efficient—that is, the fastest and the most accurate.

The problem has both theoretical and practical significance. Theoretically, the experiment has some bearing on the laws of trial and error learning. For instance, is practice of the correct response more important for learning than no practice of such response, or than practice of the wrong response? Again, after a disrupting error, is a new start from the beginning, without immediate correction of the error, more significant for learning than practice of the correct response immediately after an error without the factor of a new start from the beginning?

From a practical standpoint, solutuion of the problem appears to be a significant educational experiment, since the best method, when once discovered, should be applicable to school work involving serial rote learning.

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[1] This study was suggested by Professor Henry E. Garrett, who gave constant encouragement and assistance throughout.

It has been found that some errors are necessary before a task can be learned. Ludgate (28) has shown, for instance, that complete prevention of errors by manual guidance inhibits learning. The majority of errors made by learners, however, must be unlearned before the task is completed. Therefore, the most efficient method will be that one which minimizes the total number of errors, prevents the continued repetition of specific errors, and requires the least amount of time.

## 2. Review of the Literature

One of the earliest approaches to this problem of efficiency of learning was concerned with the question of whole versus part learning. The controversy began in 1900 when Steffens (53) noted that her subjects, if left to their own devices, learned poetry and nonsense syllables by the part method. She found that it was much more economical to learn the whole task from the very beginning than to learn one part thoroughly before going on to the next part. This was found to be true in spite of the fact that her subjects preferred the part method and had to be instructed in the use of the whole method. These results were verified by various other investigators like Larguier des Bancels (25), Pentschew (36), Neumann (33), Pyle and Snyder (46), Lakenan (23) and Brown (3).

At first, the evidence seemed in favor of the whole method. Later, the part method appeared more efficient. In 1917 Pechstein (34) proposed a progressive part method as the best method. He tried out the whole method and variations of the part method in experiments on maze learning. The pure part method involved learning the separate parts of the maze, and then connecting the parts together. The progressive part method required the subjects to master each part before it was added to the previously learned part. The direct repetitive method consisted of mastering Part I, then going back through Part I before starting to learn Part II. When Part II was mastered, the subject started at the beginning and went through Parts I and II before taking Part III, and similarly for Part IV. Thus, the learned sections were reviewed before the strange sections were entered. In the reversed repetitive method the subjects learned Part IV first, then III and IV, then II, III, IV and finally I, II, III and IV. In this last method they began with the new thing and ended with the familiar. Pechstein concluded that: 1) (34) the whole method was superior to the pure part method; 2) (34) the progressive part method proved the most efficient when both nonsense syllables and mazes were used. In a later study Pechstein found that the progressive part method was superior when the practice was massed (35). Pechstein's results were criticized severely by Hanawalt (16) because the former's subjects were too few in number and were untrained in the method and because the maze was too short and its parts too similar. When Hanawalt increased the number of subjects and also improved the maze, she discovered that the order of effectiveness for the five methods was: whole, pure part, direct repetitive part, reversed repetitive part and progressive part. Other evidence in favor of the part method was supplied by Barton (1) in maze learning and by Reed (47) in logical prose and poetry. Seagoe (51) defined parts qualitatively rather than in terms of length of units and found that part learning was superior to whole learning where the parts constituted a stronger figure than the whole. If the whole mass made a stronger figure, then the whole method was superior. Although Crafts found that whole learning was superior to part learning with material that is not serially related (7), as in card-sorting, there is no difference between the two methods when the material is both non-serial and non-spatially related, as in simple letter-number substitution. Cook (5) reported that the part method was superior to the whole method when his subjects were permitted to use vision in solving his spider maze, but with subjects blindfolded (6), the part method proved best only in respect to errors, while in trials and total time the whole method was best.

The results are not decisive partly because the differences found between the part and the whole methods have not been very great, sometimes not even reliable, and show little consistency from material to material. Moreover as Reed (47) showed, individuals do not always do their best by the method most efficient for the group. Yet on the whole, the majority of the studies argue for the progressive part method. The disagreement in the various studies probably arises from the non-comparable factors present in the various experiments and from the tendency to restrict results to given specific conditions. For instance, the whole method is most advantageous when used with brighter students and those who have had some practice in using this method (51). It is most adaptable to material that is long, spatially connected and logical (8). It also is more effective with distributed practice periods. Various reasons have been advanced to account for the superiority of the whole method (2), such as: 1) it teaches the task as it is to be later used; 2) it aids the logical meaning and unity of a verbal task; 3) it eliminates the necessity of reconnecting the smaller learning units into a whole and eliminates the formation of false associations between the last item and the first item of each part.

The part method is at its best with the duller students, with short, unconnected material, and with massed practice (2). Any advantage in using the part method arises from the fact that, 1) it breaks up long material into economical units and avoids diminishing of returns that so often arises from too long a task; 2) it prevents the subject from being discouraged or fatigued by a long task and allows more visible accomplishment; 3) it permits positive transfer to operate from one part to another.

These part-whole studies have been concerned with finding the method that will generally reduce the total errors and the time of learning. Other investigators have been interested in developing a technique not only to increase the accuracy and speed of learning but also to lessen the possibility of the recurrence of a particular error. They recognize the disturbing effect of errors and so concentrate more closely on their eradication.

Culler, in a study of typewriting, card-sorting and discrimination reactions, was one of the earliest to recognize this. He says:

> ''An error committed in practice tends to introduce interfering associations which will cause other errors. In some cases this interference has a general effect which causes various errors; in other cases it has a specific effect which causes a repetition of the error in succeeding trials'' (9: 79).

He noted that errors bunch together with intervening periods of no errors. He decided that this grouping of errors does not occur merely by chance but that introspections and records tend to show that an error, by the very fact of its occurrence, makes an interference which is hard to overcome.

Lashley (26) believed that one way to reduce errors was to distribute the practice periods, for, when the trials were separated by twenty-four hours, there were not only fewer errors but also fewer identical errors on the last trial of one day and on the first of the next day. Evidently, the time interval between practice periods led to more variability in the learning because of the loss of conflicting habits and attitudes developed in the first trial.

Another method of eliminating errors is to punish the subject when a particular mistake is made. Lorge (27) verified with physical punishment what Thorndike (56) and others had found in symbolic punishment, namely, that its effect is specific and cannot be relied on to eliminate the response. Stephens showed that the mere fact that something happens after a response tends to strengthen the response (54). Reward added to this strengthening effect and punishment detracted from it, if given by a spoken word. Punishment given by the medium of a flashing light stamped the response in, however. Not all punishment will remove wrong responses. Moreover, punishment of the right responses (as electric shock on a punch board maze) will often stamp them in, as Bretnall and Hall (57) have found.

Dunlap (11) has offered a means of eliminating errors in his Beta hypothesis of negative practice. He argues that voluntary repetition of an error with intent of eliminating it results in its elimination. Dunlap found that typing-errors, like writing "hte" for "the" were more readily eliminated by voluntary reproduction of the errors than by correction of the errors. Children could be cured of their stuttering, he also asserted, by having them try to stutter voluntarily. Holsopple and Vanouse (20) had eleven students, who were constantly making errors in typing, repeat some of the errors and practice the correct form of the remaining errors with the result that the errors were more readily corrected by their repetition than by an equivalent amount of practice on the correct form of the word. Kellogg and White (22) conducted an experiment in which one group of subjects learned mazes by ordinary procedure. One repeated the error immediately after it was made, and a third group retraced in the true path near the blind alley as long a distance as that of their error. The subjects who repeated their errors learned the task with fewer total errors than did those who corrected their errors and with slightly fewer errors than those who retraced in the true pathway the distance covered in the blind alley. Ruhl (49), on the other hand, found no significant difference in accuracy of learning between those subjects who repeated their errors and those who corrected their errors. Wakeham (58) found that repetition of an error, like "funf" cured him of that habit but caused him to leave off the final letter on other words to which it belonged. Feldman (13) worked with grammar school children and found that those who had negative practice of their errors eliminated the errors less rapidly than those who had positive practice. There is not complete agreement here as to the efficacy of this technique, and there is room for much more experimentation.

A method of treating errors that has not been very widely employed is to require a new trial whenever a mistake is made. Peterson (42) tried out this scheme in his mental maze but, as far as we know, made no comparisons with the usual method of promptly correcting the error before proceeding. What he was interested in was whether learning was possible under such conditions, as he thought this procedure kept frequency and recency factors from operating. Recency was disfavored because the subject would forget what the correct response was by the time he went all the way back to the beginning and came to the choice again. Frequency was disfavored because the subject could not practice the correct reaction until he came to it again in the new trial. With the ''normal'' method the subject had the practice both of correcting the error at the time of its occurrence and also when he came to that choice of response on the second trial. The fact that learning was possible under such conditions indicated to him that frequency and recency factors were not essential to learning. However, Peterson did not compare his results with the ''normal'' method of correcting the error to determine which was the more important. As for his conclusions, we cannot be sure the time interval involved in going back to the beginning is long enough to put recency at a disadvantage.

Those familiar with the Porteus (45) mazes know that Porteus had his subjects begin over again on a new test sheet every time they made a mistake. Porteus says his purpose was partly to impress on the subjects the seriousness of their mistakes and partly to insure against accidental success. The fact that an error occurred indicated to him that the successful arrival up to this point in the maze may have been accidental and a new trial would soon show this up. He was also interested in seeing whether that particular error would occur again on the second trial. His technique was for practical purposes and offered no comparisons with any resunlts from the usual methods of correcting errors at the time that they are made.

Holmes and Carmichael (19) reported a study of this kind at the Ninth International Congress of Psychologists in 1929. These investigators had one group of subjects start their stylus back at the entrance of the maze whenever they entered a blind alley. The control group backed out of the blind alleys as best they could and went on to the end of the maze. The experimental group who used the method of ''interrupted partial responses'' proved to have 87% fewer errors than the control group. However, the total, and mean time, scores show no difference between the groups, although the median and modal times do show a superiority for the control group. The differences between the experimental and the control groups were not so great in the relearning period after two weeks. When the subjects drew the mazes from memory, the experimental group showed more retention of the blind alleys than did the control group. Holmes and Carmichael interpreted this result as indicating that the sudden change produced by interrupting the responses and bringing the subject back to the beginning merely caused him to avoid the wrong response rather than fixate the correct one in memory. As the number of subjects in each group was only 10, Holmes and Carmichael did not feel justified in drawing any general conclusions. They did use their results, however, as an argument against Peterson's completeness of response theory. Peterson claimed that those responses in any learning situation that lead to the most complete act are kept, and those that hindered the completion of the act are discarded by the organism. Holmes and Carmichael's findings that the interrupted method was superior were only incidental. Their real interest was in showing that the superior method did not allow the subject to make the consummatory response until he had completely mastered the maze without errors.

Scott (50) recently carried on a more extensive experiment with three hundred and seventy-four subjects. He used three experimental groups, each of which had to start over again on making an error and three control groups, each of which was allowed to correct its errors and go on. He also used mazes of three sizes so that there was one Experimental and one Control group for each size of maze. The groups that learned the short maze and those that learned the middle sized maze were given the usual directions, while the two groups learning the long maze were given more instructions in the form of visual demonstration of a small trial maze and additional directions for use of the verbal method—the most efficient way to solve mazes. The best method was found to be that of correcting one's errors immediately before proceeding with the rest of the maze, when the subjects were learning the small mazes without any additional help. The method of starting over again on making a mistake was superior where the maze was large and the instructions were more adequate. Evidently, the subject who works on the smaller maze with the sparse instructions does not sufficiently understand the construction of the maze to benefit by going back to the beginning. He does not know where the goal is located so that he has little at which to aim and no reward until he finishes the whole learning process. Where there are fuller instructions, the subject can get along better without knowledge of the goal. Scott says that the subject can then really take advantage of the one error method which makes him limit his attention to those parts of the maze which he can cover without error.

# CHAPTER II

## 1. The Plan of the Experiment

The present experiment was planned in order to compare the foldowing methods of serial learning upon equivalent material:

Method I. Beginning over again before correcting the error.
Method II. Going back one step before correcting the error.
Method III. Not correcting the error.
Method IV. Correcting the error as soon as it occurs.
Method V. Repeating the error.

1. Method I is similar to a part method in that the subject rarely goes through the whole task in each trial except at the end of the learning period. In the pure part method the experimenter arbitrarily divides the learning task into three or four equal parts and then has the subject learn each part before tackling the next succeeding part. In our method the subject proceeds only as far as he can without making an error on each trial. Here the amount of material that the subject tries to learn on each trial is not fixed in size but depends on where the error occurs.

2. The intercomparisons are increased so that the method of a ''new start'' or Method I can be seen in relationship to four other methods—that of partially interrupted responses (going back one step), that of going on without correcting errors, the method of correcting errors as they occur, and finally, that of repeating the error. As far as we know, these five methods have not all been used in any one study before.

3. Our subjects differed from those in the other studies in that they were children. Most of the experimenters used adult graduate students as the more readily available material. Feldman's (13) experimental proof of the inefficiency of the Beta method (Method V in our experiment) indicates that it should be tested further before accepting Dunlap's arguments. The most efficient method of adult learning is not necessarily the most efficient method for children. Serial rote learning, with which these methods are to be tried, is probably more common in grammar school than later, where the learning is more apt to be conceptual. It is less likely that children will have built up habits of work that interfere with their learning by new methods. Finally, although they probably fatigue more readily than adults, children are usually more easily motivated for a rote learning task than are adults.

4. The number of subjects in the present experiment is seventy-five for each method, as compared with the ten that Holmes used, and the sixty in each of Scott's groups.

5. The material employed is different from the mazes used in Holmes, (19) and Scott's (60) studies, which more clearly approach our study. Holmes and Scott used stylus mazes and blindfolded their subjects. We shall use two kinds of material, one which is predominantly sensori-motor and one which is more verbal and rational. The Punch Board Maze, which is the motor task, also involves the use of vision. It was thought that this would be of interest in the light of Scott's experiment, which indicated that the part method was superior with vision permitted but that there was no difference when the subjects were blindfolded. The Peterson Rational Learning Test was the verbal task. Peterson did not use this test in his experiment (41) on starting over again when an error occurred, as he developed it much later than the Mental Maze, the test on which he tried this method.

6. Instead of equated groups, we have employed a five-fold system of rotation or counterbalanced order so that each person can be compared with himself on the five methods. This scheme has the effect of ruling out the factors of individual differences, practice effect and interference effects between the methods.

7. Finally, we were interested not only in comparing total errors and time in the five methods but also in seeing whether a specific error will disappear more readily under one method than under another, that is, which method leads to the most variability and the least perseveration of responses. None of the experiments involving the return to the beginning with each error has done this.

## 2. THE TESTS

As noted above, the materials used in this experiment were the Peterson Rational Learning Test and a Punch Board Maze designed after one used by Tolman (57) and Muenzinger (32).

In the Peterson Rational Learning Test the subject must learn to associate certain numbers with certain letters. The number of letters is usually varied from 3 to 12 or so. A five letter set-up was chosen for our experiment, as this was the task used by Peterson in a study of rational learning in ten-year-old children. The experimenter assigned one of the numbers 1, 2, 3, 4 and 5, to each of the letters A, B, C, D and E, in a chance order. The following five forms were drawn up:

| Forms | Letters | | | | |
|---|---|---|---|---|---|
| | *A* | *B* | *C* | *D* | *E* |
| A | 1 | 3 | 2 | 5 | 4 |
| B | 2 | 5 | 1 | 3 | 4 |
| C | 5 | 2 | 4 | 1 | 3 |
| D | 3 | 1 | 4 | 2 | 5 |
| E | 4 | 1 | 5 | 3 | 2 |

In making up the forms the experimenter tried to have as few repetitions of the same number for a particular letter in the different forms as possible. It was not possible to carry out this rule perfectly, as there were too many numbers to arrange. However, there was usually not more than one letter-number combination in each form that was duplicated in another form, though in two forms there were two repetitions.

The advantages of the Peterson Rational Learning Test are that: 1) it shows little practice effect, that is, less improvement from one application to another than do many other tests; 2) it obviates language difficulties and gives practically the same results for children of different racial and social background; 3) it makes it easy to record the responses objectively and does not demand that one watch the overt responses and also record them, as in the Punch Board; 4) it is rational to the extent that it involves the keeping in mind of a large number of responses at one time, the limiting of the range of guesses for the other letters by remembering the responses to the first letters, close attention to detail and altogether an active organization of memory and objective attitude. Peterson (39) says that the person who succeeds has an objective attitude and avoids perseverative errors (saying the same wrong number over again for one letter) and logical errors (saying the number learned for a previous letter for a later letter) ; 5) Peterson (43) believed that the Rational Learning Test was a good intelligence test since it correlated highly with teachers' estimates and with Binet tests of intelligence. Correlations with intelligence tests range from .37 with the Binet to .53 with the Myers mental measurement. Lamb (24) and Haught (17) found much lower correlations. Lamb (24) found that the Peterson Rational Learning Test correlated .005 with a code test, .13 with a Turkish-English vocabulary, –.14 with digit symbols, and .14 with logical memory. Garrison (15) found a correlation of .51 with the Army Alpha and .63 with Otis. Haught (17) found a correlation from .23 to .27 between the Peterson

Rational Learning Test and percentile scores on intelligence tests (6). Garrison (15) found high reliability coefficients for the Peterson Rational Learning Test. The correlation between two equivalent eight-letter forms for college students, for example, averaged .67 (.75 for time, .60 for trials, and .70 for errors). The internal consistency measured by correlations between odd and even trials was .92 for unclassified, .90 for logical and .64 for perseverative errors, according to Haught (17) who used a ten-letter form with college students. Heron (18) corroborated, also with college students, the size of the equivalent form reliabilities, for he found .58 for time, .48 for trials, and .57 for errors on ten and fifteen-letter forms.

The Punch Board Maze in this experiment was suggested by the maze used by Tolman (57) and also by Muenzinger (32) in investigations designed to discover whether learning could take place when adult subjects were shocked upon making correct responses, As we were not interested in the punishment aspect of learning, we did not wire the holes in the maze for the administration of electric shocks. Moreover, instead of having thirty pairs of holes arranged in an irregular manner over the board, we had three rows of ten pairs of holes each, though we afterwards found it best to have our subjects learn just one row. The pairs of holes in our punch board were arranged regularly in a row to make the learning more unified and more within the limits of children's learning ability. The board itself was one-fourth of an inch thick and ten and a half by ten and a half inches. The subject's task was to learn which hole in each pair was the correct one to punch with his pencil.

It was possible to make up five forms of the Punch Board to correspond to the five forms of the Petersonal Rational Learning Test. The correct hole in each pair was sometimes located on the subject's right, sometimes on his left, in a chance or haphazard order.

Location of the Correct Hole

(L means the correct hole is on the left side of the subject as he faces the board and R means the correct hole is on the right side)

| | |
|---|---|
| Form A | LLRLRRRLRL |
| Form B | RRRLRLLLLR |
| Form C | RLLLRLRRLR |
| Form D | LRRLLRLRRL |
| Form E | LRRLRLLRLR |

The Punch Board differed from the Peterson Rational in that: 1) it offered ten dual choices instead of five multiple choices; 2) it necessitated the use of vision. This is an interesting difference Cook found that vision brought out the advantages of the part method more than did tasks where the subject was blindfolded (5); 3) it was more motor and less symbolical than the Peterson Rational Learning Test. Although it is true that maze learning involves verbalization and the use of the higher central processes to some extent, still it necessitates more overt movements than does a purely verbal task like the Peterson Rational Learning Test.

It was thought that the two tasks were different enough to be more representative of serial learning than would either alone. They both: 1) involve the discovery of the right response by guessing; 2) were composed of a series of somewhat similar units, any one of which could be isolated for further study; 3) lay greater stress on the elimination of errors than upon pure memorization of the correct responses; 4) consisted of serial rote, trial and error material that is artificial in nature but simple enough to be learned quickly and to be analyzed statistically; 5) obviated the use of language except in the instructions; 6) had high reliability. The reliability between odd and even trials on the Punch Board maze of 30 pairs of holes used by Tolmon (57) ranged between .92 and .97.

## 3. PROCEDURE

The subjects were tested individually in a small office room in the public school. A one-way screen was made of black cellophane so that if the child was placed between the source of light in the room and the screen, with the experimenter on the other side, the child could be seen. However, he could not see the experimenter taking down his responses or timing him with the stop watch. For this reason he was not made nervous by the testing, nor could he get clues from watching the experimenter to help him learn the test more quickly. The subject was seated at a small table with the punch board placed squarely before him, and then given a pencil with which he was to punch the holes. He was told to start at the end of the board nearest himself and to work in the direction toward the experimenter.

There was no specific apparatus for the Peterson Rational Learning Test. The subject merely sat down at the table and guessed numbers out loud which the experimenter took down behind the one-way screen. During all the learning sessions there were the usual schoolroom noises in the hall outside of the testing room, but the children were working under conditions that were identical or possibly better than those of their regular everyday school life.

Every child was given both tests to learn at a single sitting. The order of the tasks was rotated, one half of the subjects starting their session with the Peterson Rational Learning Test each time and one half with the Punch Board. Those who had begun with the Peterson Rational Learning Test at the previous session, started off with the Punch Board at the next session, and *vice versa.* This procedure ruled out the advantage which might follow from having one test as the initial task all the time. Both tests were short enough to be completed in one session of twenty or thirty minutes. This kept the child from being fatigued and also made possible the complete learning of the task at one session.

Before the first session the Experimenter took each child singly out of the class room and explained that he was to be given a puzzle that would not in any way affect his grades; that she was simply interested in seeing how well ten and eleven-year-old boys and girls could accomplish it. The Experimenter then read the following instructions to the children, as it was thought that it could be understood better that way than by having them read the instructions themselves. The instructions for the Peterson Rational Learning Test were as follows:

> "The letters A, B and C are numbered 1, 2 and 3; but A may not be 1, B may not be 2, and C may not be 3. They are numbered just by chance. Now I am going to call out A, and you must guess until you find the number that goes with A. I shall tell you when you get it right, and shall then call out B. When you guess the number for B, I shall call out C. All you have to do is to remember the number that goes with each letter so that you can give all the numbers without making a mistake. Remember that all the letters have different numbers."

The Experimenter then called out A and recorded all the responses until the subject guessed 3. The same procedure was carried out for B–1 and C–2. If the subject guessed a number above 3, he was told that

> "there are only three letters so that the number cannot be higher than 3."

When the child was able to get through this fore-exercise twice in succession, the Experimenter then said:

> "I am going to give you five letters, A, B, C, D and E and numbers from 1 to 5, and you are to guess which number goes with which letter. The first time you go through it, I'll let you keep on guessing for each letter until you get the right number. After that, before you start it again, I'll tell you the way that I want you to

learn it. Remember, you must keep on until you can give the right number for each letter twice in a row."

The stop watch was then started at the signal of "go" and stopped when the subject completed the learning to the criterion of two successive trials without errors.

The following instructions were read for the Punch Board:

> "Here are ten pairs of holes into each of which you can put your pencil. (Subject was to count them at this point.) Only one hole in each pair is the correct one to punch. I want you to go through the whole ten pairs the first time, punching whichever one you might think to be the correct one. If it is the correct one, I shall tell you so and you are to go on to the next pair. If it is the wrong one, I shall say "wrong" and you are to correct it. After you have been through this way once, I shall tell you how I want you to learn it the next times. Remember you must be able to go through the ten pairs of holes without any error twice in a row."

After the subjects had been through the problems once and had corrected their errors as they occurred, they were given the following instructions for the particular method in which they were to be tested:

*For Method I*

> "Every time you make a mistake you must start over again at the beginning without taking time to correct your mistake."

*For Method II*

> "Every time you make a mistake you must go back one step and then go on from there to the place where you made your mistake and try to get the number or hole right this time. For instance, if you make a mistake on Letter E, you will have to tell me the number for Letter D and then try Letter E again."

*For Method III*

> "If you make a mistake you must not correct it but keep right on."

*For Method IV*

> "You'll keep right on the same way as on the first trial, correcting your mistakes as it occurs."

*For Method V*

> "If you make a mistake, I shall have you make it again purposely so that I can say "wrong" to you twice."

As the instructions indicated, the subjects went through the Punch Board Maze and the Peterson Rational Learning Test by the "normal" method first, that is, correcting the errors and going on.

The data on this trial was later discarded. The advantage of this procedure was that: 1) this trial served as a fore-exercise and practice period, which gave the subjects a chance to find out what they were expected to do; 2) the subjects all started off on the same level since they had all been through the task and reached the goal once, before they began the individual methods of learning. If this scheme had not been followed, those who began with the method of returning to the beginning with each error would never have been able to get through the whole task until the very end when they had learned it perfectly. Scott's experiment indicated that the one-error method was effective only when added instructions compensated for the subjects' inability to reach the goal until the end of the task (50). We thought that all the subjects should have some knowledge of the end of the goal or task before they started to learn. 3) There was less opportunity for chance to play a part in the results. We were interested not in the subjects' ability to discover by luck what the correct response was but to remember once they had been told what was right. Cook (6) showed that there was no difference between the part and the whole method on the first trial but that there were differences on the remaining trials. In other words, the data on the first trials and those on successive trials were correlated to a very small extent.

The standard of learning, according to the directions given to the children, was two correct successive trials. This is the standard used by Peterson in experiments with the Rational Learning Test; hence, it was used in our experiment on both tests to make the results comparable. An error was defined as actual contact of the pencil with the hole in the Punch Board Maze and in the Peterson Rational Learning Test as actual verbalization of the letter. An error that was spontaneously corrected before the experimenter could say "wrong" was not counted. The efficiency of the learning by the different methods was measured by: 1) total number of errors; 2) total time. Number of trials was not used, because the method of starting over again on making an error necessarily made the trials incomplete.

## 4. SUBJECTS

One hundred and fourteen children from the fourth to the sixth grades in P. S. 169, New York City, were used for the experiment. The records of the first thirty-six children were discarded because of certain inevitable changes in the rotation schedule which had to be made, and the records of thirty-six other children were substituted for them. Of these seventy-eight subjects, the records of three had to be thrown away because of fire-drills and other unforeseen emergencies and interruptions, so that there were seventy-five subjects left for the Punch Board Maze and seventy-four for the Peterson Rational Learning Test. Seventy of these subjects were identical for the two tests, so that they can be compared in these two respects. Three of the children included in the Punch Board Maze data could not be used for the Peterson Rational Learning Test and two of those on the latter could not be used in the data on the Punch Board.

Only those children were selected for either task whose I.Q.'s on the National Intelligence Test fell within the normal range. (A few had only the Pinter-Cunningham Intelligence Test.) Results from average children, of course, will be more typical than results from very bright or very dull children. The mean I.Q. of the seventy-four children who took the Peterson Rational Learning Test was 104 with a $\sigma$ of 7½ points and a range from 87 to 115 points. The average chronological age was ten and a half years with a $\sigma$ of four months and a range from nine years, four months, to eleven years. The average I.Q. of the seventy-five subjects who worked with the Punch Board was 104, $\sigma$ of 7 points and a range from 87 to 115. The average chronological age was ten and a half years, with a $\sigma$ of four months and a range from nine years, four months, to eleven years.

Table I presents this description of our subjects.

As mentioned before, the children were divided into five groups for purposes of rotation. At the beginning of the experiment, the groups were equal in number, but due to absence and later additions to make up for the absences, the groups at the end of the experiment were not all equal in number. As table I shows, the five groups were practically equal in mean I.Q. and mean C.A. and also in the relative scatter around these means.

### 5. TESTING SCHEDULE

A five-letter form of the Peterson Rational Learning Test and the ten pair of holes form of the Punch Board Maze were given in a preliminary series to ten nine- and ten-year-old children in the public schools of Ridgewood, New Jersey. It was found that neither of the tasks took longer than fifteen minutes when Method IV was used, and most of the children were able to finish in five to ten minutes. This period was short enough not to fatigue the subjects.

### TABLE I

### Intelligence and Chronological Age of Our Subjects

(A) *Peterson Rational Learning Test*

| | *Groups* | | | | | |
|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *Mean* |
| Mean I.Q. | 105.64 | 104.65 | 103.07 | 101.93 | 104.63 | 103.98 |
| σ | 6.33 | 8.08 | 6.69 | 6.83 | 9.50 | 7.49 |
| Range | 92–115 | 87–115 | 91–113 | 89–111 | 88–114 | 87–115 |
| Mean C.A. | 10–6* | 10–5 | 10–5 | 10–4 | 10–8 | 10–6 |
| σ | 4 mos. | 5 mos. | 3 mos. | 3 mos. | 4 mos. | 4 mos. |
| Range | 9–11 to 11 | 9–4 to 11 | 10–0 to 10–10 | 10–1 to 10–10 | 9–11 to 10–10 | 9–4 to 11 |
| Number in Group | 14 | 17 | 15 | 15 | 13 | |

(B) *Punch Board Maze*

| | *Groups* | | | | | |
|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *Mean* |
| Mean I.Q. | 105.36 | 104.65 | 103.71 | 101.93 | 104.73 | 104.08 |
| σ | 6.10 | 8.08 | 6.61 | 6.83 | 9.16 | 7.36 |
| Range | 92–115 | 87–115 | 91–113 | 89–111 | 88–114 | 88–115 |
| Mean C.A. | 10–5* | 10–5 | 10–5 | 10–4 | 10–7 | 10–6 |
| σ | 5 mos. | 5 mos. | 3 mos. | 3 mos. | 4 mos. | 4 mos. |
| Range | 9–11 to 11 | 9–4 to 11 | 10–0 to 10–10 | 10–1 to 10–10 | 9–11 to 10–10 | 9–4 to 11 |
| Number in Group | 14 | 17 | 14 | 15 | 15 | |

* 10–5 means 10 years, 5 months.

remained about the same, however, as in the first session, since the Also, the tests were interesting so that full cooperation was obtained from the children.

After the preliminary experiment, the actual experiment was begun in a New York City school. Children were taken from the class room one at a time and tested individually. There was no time interval between the two tasks, as a first group of subjects whose records were later discarded indicated that they did not want the rest period. The entire testing period rarely took more than twenty minutes, so that fatigue results were negligible. Practice was massed, so that the learning could be carried to the criterion of two perfect trials at one sitting. From the second session on, the subjects were first tested for their retention of the task learned two weeks before, and then given the new task. The length of the session learning task was done in less time in later sessions with the relearning time included than in the first session.

Motivation was kept as constant as possible throughout the experiment. It consisted of being able to complete the task in one session and also probably in hearing the Experimenter say ''right'' instead of ''wrong.'' The children maintained their enthusiasm for the tests until the end of the third session. As interest began to lag, each child was given a small ten cent store gift before he began his task. These incentives were a constant factor for all groups.

The following testing schedule was drawn up and followed from January 4th to April 11, 1937.

TABLE II

METHODS OF LEARNING AND FORMS OF THE LEARNING TASKS GIVEN TO THE FIVE GROUPS IN THE FIVE LEARNING SESSIONS FOR PETERSON RATIONAL LEARNING TEST AND PUNCH BOARD MAZE

| *Sessions* | *Groups* | | | | |
|---|---|---|---|---|---|
| | *I* | *II* | *III* | *IV* | *V* |
| First | Method I<br>Form A | Method II<br>Form B | Method III<br>Form C | Method IV<br>Form D | Method V<br>Form E |
| Second | Method II<br>Form C | Method III<br>Form E | Method V<br>Form A | Method I<br>Form C | Method IV<br>Form C |
| Third | Method V<br>Form D | Method I<br>Form D | Method IV<br>Form B | Method III<br>Form A | Method II<br>Form A |
| Fourth | Method IV<br>Form E | Method V<br>Form C | Method I<br>Form E | Method II<br>Form E | Method III<br>Form D |
| Fifth | Method III<br>Form B | Method IV<br>Form A | Method II<br>Form D | Method V<br>Form B | Method I<br>Form B |

The two variables, method and form, were rotated among the five groups of subjects and the five testing periods so as to equalize the effect of practice and other factors. The symmetrical arrangement in Table II follows as closely as possible what Fisher (14) has called a ''Latin Square.'' This counterbalance helps rule out the following extraneous factors:

1. *Practice Effect.*

   Each of the five groups employed each of the five methods but in a different order. This kept any one method from being favored or disfavored by practice. Method I, for example, comes first with Group I, third with Group II, fourth with Group III, second with Group IV and last with V where there is a maximum practice effect.

2. *Inequality of Forms.*

Since each subject would eventually use all five methods, it was necessary to have five different arrangements for each task. This was done: 1) to insure that the learning task would be equally new for all methods, and 2) that no method should have the same form twice, and 3) to equalize differences that might exist between the forms. Method I, for example, has Form A in Group I, Form D in Group II, Form E in Group III, Form C in Group IV and Form B in Group V.

3. *Inequalities of the Groups.*

The groups were equated as to size, sex, age, general level, but undoubtedly incidental or accidental differences still remained. The arrangement in Table II was designed to eliminate such factors, since each group had eventually a chance at all the methods and at all the forms.

4. *Transfer Effect.*

Our goal was to insure that a given method should not precede or be followed by the same method twice, as this would make positive or negative transfer to certain methods unequal. Thus, if Method IV is followed by Method III in Group I, it should not be followed by Method III in the other groups. It was found that when the methods were rotated among the five groups and the five learning sessions, the relations of methods in the schedule could be perfectly controlled.

5. *Individual Differences.*

A major advantage of the rotation method is that the same subject can be given all five methods. Since each subject's score can be compared from one method to another, any differences found between the methods can be assumed to be due to the factor experimentally introduced—different methods—and not to the subjective variation of learning from one subject to another.

# CHAPTER III

## Results

### 1. *Reliability*

The reliability of the Peterson Rational Learning Test and the Punch Board Maze was first computed before the methods were compared. The split-half reliability (found by correlating errors on odd pairs of holes with those on even in the Punch Board) averaged

TABLE III

Reliability Coefficients (in Terms of Correlations Between Errors)

(A) *Peterson Rational Learning Test*

| | *Method* | | | | | |
|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *Average* |
| Correlation between learning and relearning scores | +.03 | +.24 | +.34 | +.45 | +.27 | +.27 |
| Split half correlation raised by Spearman-Brown Prophesy Formula | +.48 | +.68 | +.78 | +.81 | +.87 | +.72 |

* r was between errors on first and fourth letter and those on second and last letter. Then by $\frac{nr}{1+(n-1)r}$ where $n = 1.25$ it was raised to what it would be if all five letters were used.

(B) *Punch Board Maze*

| | *Method* | | | | | |
|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *Average* |
| Correlation between learning and relearning scores | +.31 | +.55 | +.34 | +.21 | +.23 | +.33 |
| Split half correlation between odd and even pairs of holes raised by S. B. Prophecy Formula | +.83 | +.63 | +.91 | +.90 | +.89 | +.83 |

+.83. Methods III, IV and V have the highest split-half correlations and Method II the smallest. In the Peterson Rational Learning Test the errors on the first and fourth letters were correlated with those on the second and fifth, and the correlation was raised by the Spearman-Brown formula to what it would have been had the errors on the third letter been included. The average r here was +.72. The correlation between learning and relearning scores was necessarily lower, being +.27 for the Peterson Rational Learning Test and +.33 for the Punch Board Maze. These reliabilities are not as high as those found by Peterson and others, but the differences probably lie in the shortness of the test and the homogeneity of the group. The longer the test and the greater the heterogeneity of the group, the greater the reliability.

### 2. *Intercorrelations*

In order to obtain the correct standard deviation with which to test the differences between groups, one must take account of the correlations between groups. The Tables show the correlations between errors made by the five methods.

It is interesting to compare the intercorrelations between the five different methods for learning errors with learning time and with relearning errors and relearning time. The correlations ranged from +.11 to +.38. The highest correlation was that between mean time for relearning the Peterson Rational Learning Test by the five methods and the next highest was that between mean errors for relearning the Peterson Rational Learning Test. The lowest correlation was between mean time scores for learning the Punch Board Maze.

TABLE IV

(A) *Correlations between Mean Errors for Learning the Peterson Rational Learning Test*

| *Method* | *r* | *Method* | *r* | *Method* | *r* |
|---|---|---|---|---|---|
| 1 and 2 | +.37 | 2 and 3 | +.40 | 3 and 4 | +.52 |
| 1 and 3 | +.32 | 2 and 4 | +.22 | 3 and 5 | +.01 |
| 1 and 4 | +.42 | 2 and 5 | +.06 | 4 and 5 | +.34 |
| 1 and 5 | +.32 | | | | |

Mean for all r's is +.30.

(B) *Correlations between Mean Errors for Learning the Punch Board Maze*

| *Method* | *r* | *Method* | *r* | *Method* | *r* |
|---|---|---|---|---|---|
| 1 and 2 | +.32 | 2 and 3 | +.18 | 3 and 4 | +.27 |
| 1 and 3 | +.08 | 2 and 4 | +.40 | 3 and 5 | +.25 |
| 1 and 4 | +.47 | 2 and 5 | +.11 | 4 and 5 | +.04 |
| 1 and 5 | +.20 | | | | |

Mean for all r's is +.23.

The formula for the $\sigma$ of the difference becomes

$$\sigma D = \sqrt{\sigma^2 av_1 + \sigma^2 av_2 - 2r\, \sigma av_1 \sigma av_2}$$

### TABLE V

(A) *Correlations between Average Times for Learning Peterson Rational Learning Test by the Five Methods*

| *Method* | *r* | *Method* | *r* | *Method* | *r* |
|---|---|---|---|---|---|
| 1 and 2 | +.33 | 2 and 3 | +.40 | 3 and 4 | +.44 |
| 1 and 3 | +.18 | 2 and 4 | +.25 | 3 and 5 | +.01 |
| 1 and 4 | +.44 | 2 and 5 | +.04 | 4 and 5 | +.36 |
| 1 and 5 | +.33 | | | | |
| Mean for all r's is +.28. | | | | | |

(B) *Correlations between Mean Times for Learning the Punch Board Maze*

| *Method* | *r* | *Method* | *r* | *Method* | *r* |
|---|---|---|---|---|---|
| 1 and 2 | +.24 | 2 and 3 | +.11 | 3 and 4 | +.16 |
| 1 and 3 | −.25 | 2 and 4 | +.34 | 3 and 5 | +.09 |
| 1 and 4 | +.35 | 2 and 5 | +.14 | 4 and 5 | −.06 |
| 1 and 5 | +.02 | | | | |
| Mean for all r's is +.11. | | | | | |

### TABLE VI

(A) *Correlations between Mean Errors for Relearning the Peterson Rational Learning Test*

| *Method* | *r* | *Method* | *r* | *Method* | *r* |
|---|---|---|---|---|---|
| 1 and 2 | +.24 | 2 and 3 | +.15 | 3 and 4 | +.44 |
| 1 and 3 | +.26 | 2 and 4 | +.35 | 3 and 5 | +.11 |
| 1 and 4 | +.42 | 2 and 5 | +.45 | 4 and 5 | +.47 |
| 1 and 5 | +.33 | | | | |
| Mean for all r's is +.32. | | | | | |

(B) *Correlations between Mean Errors for Relearning the Punch Board Maze*

| *Method* | *r* | *Method* | *r* | *Method* | *r* |
|---|---|---|---|---|---|
| 1 and 2 | −.02 | 2 and 3 | +.20 | 3 and 4 | +.24 |
| 1 and 3 | +.08 | 2 and 4 | +.44 | 3 and 5 | +.05 |
| 1 and 4 | −.11 | 2 and 5 | +.04 | 4 and 5 | +.47 |
| 1 and 5 | +.12 | | | | |
| Mean for all r's is +.15. | | | | | |

As all the correlations between the learning scores on the various methods were positive, the $\sigma$ of the difference was often considerably reduced. In most cases, however, the mean differences were large enough to be statistically significant, even if the correlation had been neglected.

TABLE VII

(A) *Correlations between Mean Time for Relearning the Peterson Rational Learning Test*

| *Method* | *r* | *Method* | *r* | *Method* | *r* |
|---|---|---|---|---|---|
| 1 and 2 | +.33 | 2 and 3 | +.33 | 3 and 4 | +.41 |
| 1 and 3 | +.28 | 2 and 4 | +.55 | 3 and 5 | +.16 |
| 1 and 4 | +.50 | 2 and 5 | +.51 | 4 and 5 | +.41 |
| 1 and 5 | +.35 | | | | |

Mean for all r's is +.38.

(B) *Correlations between Mean Time for Relearning the Punch Board Maze*

| *Method* | *r* | *Method* | *r* | *Method* | *r* |
|---|---|---|---|---|---|
| 1 and 2 | +.44 | 2 and 3 | +.11 | 3 and 4 | +.25 |
| 1 and 3 | +.36 | 2 and 4 | +.38 | 3 and 5 | +.02 |
| 1 and 4 | −.05 | 2 and 5 | +.16 | 4 and 5 | +.43 |
| 1 and 5 | −.07 | | | | |

Mean for all r's is +.20.

### 3. *Ranking of the Methods*

When the five methods were ranked in order from smallest to largest mean error, the results were as shown in Table VIII below.

1. Method I: Starting over again every time an error was made.
2. Method II: Going back one step every time an error was made.

TABLE VIII

MEAN ERRORS AND VARIABILITY IN THE LEARNING OF (A) *Peterson Rational Learning Test*

| | *Method* | | | | |
|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* |
| Total Errors | 515 | 1231 | 1483 | 1446 | 1966 |
| Mean Errors | 6.96 | 16.64 | 20.05 | 19.54 | 26.57 |
| $\sigma$ | 7.26 | 16.37 | 19.60 | 27.93 | 26.49 |
| $\sigma$(Aver.)* | .84 | 1.90 | 2.28 | 3.24 | 3.06 |
| V** | 104.32 | 98.38 | 97.76 | 142.94 | 99.70 |
| Range | 0–45 | 0–60 | 0–96 | 0–119 | 0–130 |

* $\sigma(\text{Aver.}) = \frac{\sigma(\text{dis.})}{\sqrt{n}}$

** V is $\frac{\sigma}{M} \times 100$

(B) *Punch Board Maze*

| | *Method* | | | | |
|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* |
| Total Errors | 1184 | 1697 | 2531 | 2002 | 2727 |
| Mean Errors | 15.79 | 22.63 | 33.75 | 26.69 | 36.36 |
| σ | 14.56 | 15.23 | 30.54 | 26.47 | 27.43 |
| σ(Aver.) | 1.68 | 1.76 | 3.53 | 3.06 | 3.17 |
| V | 92.21 | 67.30 | 90.49 | 97.18 | 75.43 |
| Range | 0–87 | 2–73 | 1–198 | 4–160 | 0–153 |

3. Method III: Correcting the error and going on.
4. Method IV: Going on without correcting the error.
5. Method V: Repeating the error.

The superiority of Method I over each of the other four methods is statistically significant, since the critical ratio is well over three.

This superiority of Method I is general for both the Peterson Rational Learning Test and the Punch Board Maze. In the former test Method II is significantly superior in average errors to Method V. Method III and Method IV are also almost significantly superior to Method V. The difference between the more efficient Method II and the less efficient Method III is practically significant also. The only case in which there was practically no difference was the comparison between Method III and Method IV.

In the Punch Board Maze, Method II is significantly superior to Method III and to Method V. The difference between the superior Method II and the less efficient Method IV and that between the more efficient Method IV and the inferior Method III and Method V is almost significant statistically if a critical ratio of 3 is considered as significant. The difference between Method III and Method V is not significant, however.

It is significant that the same relative rank was maintained in both learning tests, although the one task was predominantly motor and the other predominantly verbal. The advantage of going back to the beginning over the method of going back one step is greater for the Peterson Rational Learning Test than for the Punch Board Maze. The advantage of the best method (I) over the method of correcting the error was greater for the Peterson Rational Learning Test than for the Punch Board Maze. Otherwise, the relative differences are about the same. From these results it would seem that, with serial and rote material, returning to the beginning on making a mistake makes for more efficient learning, whether the material is sensori-motor or verbal. This maintenance of the same relative rank of the five methods on both materials is especially significant, when one remembers that the Peterson Rational Learning Test involves multiple choice and the Punch Board Maze dual choice. In the former test, in Method V when the subject made a mistake and was required to repeat it, he was given more chances until he guessed the right number. This slight change was instituted in the Peterson Rational Learning Test because preliminary testing had shown practically no learning in the multiple-choice problem when the subject was not allowed to correct his error after having repeated it. In the Punch Board Maze, when the subject made an error and had to repeat it, he went on to the next choice without being allowed to correct his error.

The difference in errors between Method I and Method II in both tests, although statistically significant, was the least of the differences between that method and the other method. Method I and Method II both were similar in that they involved a new start.

TABLE IX

Reliabilities of the Differences in Mean Error for the Five Methods

(A) *Peterson Rational Learning Test*

| *Methods Compared* | $\frac{D}{\sigma D}$ | *Critical Ratio* | *Significance of Differences Obtained* |
|---|---|---|---|
| 1 and 2 | $\frac{9.68}{1.77}$ | 5.25 | (Significant) |
| 1 and 3 | $\frac{13.09}{2.77}$ | 6.03 | (Significant) |
| 1 and 4 | $\frac{12.58}{2.99}$ | 4.21 | (Significant) |
| 1 and 5 | $\frac{19.61}{2.90}$ | 6.76 | (Significant) |
| 2 and 3 | $\frac{3.79}{2.31}$ | 1.63 | (94 chances in 100) |
| 2 and 4 | $\frac{3.28}{3.37}$ | .97 | (83 chances in 100) |
| 2 and 5 | $\frac{10.31}{3.55}$ | 2.90 | (Significant) |
| 3 and 4 | $\frac{.51}{2.83}$ | .18 | (56 chances in 100) |
| 3 and 5 | $\frac{6.52}{3.76}$ | 1.70 | (96 chances in 100) |
| 4 and 5 | $\frac{7.03}{3.64}$ | 1.93 | (97 chances in 100) |

(B) *Punch Board Learning Test*

| *Methods Compared* | $\frac{D}{\sigma D}$ | *Critical Ratio* | *Significance of Differences Obtained* |
|---|---|---|---|
| 1 and 2 | $\frac{6.84}{2.00}$ | 3.42 | (Significant) |
| 1 and 3 | $\frac{17.96}{3.79}$ | 4.74 | (Significant) |
| 1 and 4 | $\frac{10.90}{2.71}$ | 4.02 | (Significant) |
| 1 and 5 | $\frac{20.57}{3.28}$ | 6.27 | (Significant) |
| 2 and 3 | $\frac{11.12}{3.65}$ | 3.05 | (Significant) |
| 2 and 4 | $\frac{4.06}{2.85}$ | 1.42 | (92 chances in 100) |
| 2 and 5 | $\frac{13.73}{3.45}$ | 3.98 | (Significant) |
| 3 and 4 | $\frac{7.06}{4.00}$ | 1.77 | (96 chances in 100) |
| 3 and 5 | $\frac{2.50}{4.11}$ | .61 | (73 chances in 100) |
| 4 and 5 | $\frac{9.56}{4.32}$ | 2.21 | (98.6 chances in 100) |

Method I and Method IV were the next most similar, probably because Method I could not be applied on the first letter of the Peterson Rational Learning Test. The subject was always allowed to correct his error on the first letter, since he could not go back beyond the first letter. Therefore, Method I involved the use of Method IV on the first letter.

### 4. *Variability*

It will be recalled that individual differences were eliminated as sources of variation between the methods, since the averaging of the scores for each method and the comparing of their difference were essentially the same as if each individual's score for one method were compared with his score for the other four methods. Yet the performance variability was very large, as is shown by Table X and the task was harder to learn than the Peterson Rational Learning Test.

The greatest variability in both tests was found in the method of correcting errors as they occurred. The next greatest V was in Method I, both in the Punch Board and in the Peterson Rational Learning Test, in which case the subject went back to the beginning

## TABLE X

VARIABILITIES OF THE SCORES AROUND THE MEAN OF EACH SESSION FOR EACH METHOD

100 $\sigma/M$ for Each Session

(A) *Peterson Rational Learning Test*

| *Sessions* | *Method* | | | | |
|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* |
| I | 113.41 | 51.69 | 71.56 | 133.73 | 43.93 |
| II | 121.76 | 67.72 | 93.14 | 79.44 | 97.16 |
| III | 90.07 | 113.21 | 136.79 | 124.66 | 109.15 |
| IV | 77.04 | 114.27 | 75.16 | 128.26 | 92.45 |
| V | 65.89 | 101.28 | 69.07 | 114.04 | 94.67 |
| Aver. | 93.64 | 89.62 | 89.15 | 116.82 | 87.47 |

VARIABILITIES OF ALL THE SCORES AROUND THE MEAN FOR EACH METHOD (ALL SESSIONS INCLUDED)

(B) *Peterson Rational Learning Test*

| *Sessions* | *Method* | | | | |
|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* |
| | 104.32 | 98.38 | 97.76 | 142.94 | 99.70 |

VARIABILITIES OF THE SCORES AROUND THE MEAN OF EACH SESSION FOR EACH METHOD

100 $\sigma/M$ for the Whole Method

(C) *Punch Board Learning Test*

| *Sessions* | *Method* | | | | |
|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* |
| I | 58.39 | 63.37 | 71.28 | 53.37 | 52.86 |
| II | 106.09 | 53.41 | 83.46 | 63.46 | 82.11 |
| III | 53.77 | 48.47 | 62.66 | 89.53 | 51.32 |
| IV | 74.10 | 75.31 | 49.38 | 62.96 | 40.97 |
| V | 88.91 | 71.26 | 68.59 | 77.14 | 64.33 |
| Aver. | 76.25 | 62.37 | 67.07 | 69.29 | 58.33 |

VARIABILITIES OF THE 75 SCORES AROUND THE MEAN FOR EACH METHOD (ALL SESSIONS INCLUDED)

(D) *Punch Board*

| *Sessions* | *Method* | | | | |
|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* |
| | 92.21 | 67.30 | 90.49 | 97.18 | 75.43 |

on making an error. In the Peterson Rational Learning Test, the method showing the least V was that of not correcting the error, and in the Punch Board Maze, that of going back one step. It is difficult to understand why the best method was the most variable. Perhaps the explanation lies in the fact that the task was the shortest when this method was used, and chance variations played a larger part than in the longer methods. Also, the scores were smaller and when the variation of Method I was compared with that of the other methods, it appeared larger in reference to the smaller mean.

These large standard deviations are undoubtedly due in part to the rotation scheme employed, that is, the one method is given under so many practice conditions that the deviations are greater than in an ordinary experimental situation. The scatter of the individual scores of one group around the average of one method at one session of the learning schedule is not so large. However, the V's for the individual sessions of the Peterson Ration Learning Test are all around 90 and for the Punch Board Maze around 70. Evidently, chance can be said to play a rather important part in causing the performance variabilities. Chance factors are more or less inherent in the test, since it is so short. Probably the reason that Peterson did not find such large V's is because he used a longer test.

Variations also show up in the range of the scores. As mentioned before, each subject always went through the task once by Method IV before being given the particular method which was to be tested. The data from the first trial with Method IV was then discarded. Because some of the children were able to learn the tests after they had been through it once by Method IV on the preliminary trial

TABLE XI

NUMBER OF ZERO SCORES FOR EACH METHOD (WHERE THE SUBJECT LEARNED THE TASK AFTER HE HAD BEEN THROUGH IT ONCE ON THE PRELIMINARY TRIAL)

| *Method* | *Group* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *1* | | *2* | | *3* | | *4* | | *5* | | *Total* | |
| | PR* | PB** | PR | PB | PR | PB | PR | PB | PR | PB | PR | PB |
| I | 3 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 7 | 1 |
| II | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 5 | 0 | 6 | 0 |
| III | 0 | 0 | 2 | 0 | 0 | 0 | 5 | 0 | 1 | 0 | 8 | 0 |
| IV | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 6 | 0 |
| V | 1 | 0 | 0 | 0 | 3 | 0 | 2 | 1 | 0 | 0 | 6 | 1 |

* Peterson Rational Learning Test.

** Punch Board Maze.

before they could be tested for a particular method, there were a few zero scores. However, zeros were practically equal for the five methods, as shown in Table XI below.

### 5. *Time Scores*

Our subjects learned the Peterson Rational Learning Test in the shortest time when they were required to take a new trial upon making a mistake. On the average a minute and a half was required for Method I. Table XII shows the differences in time scores.

TABLE XII

Mean Time in Seconds for Learning by the Five Methods

(A) *Peterson Rational Learning Test*

| | *Method* | | | | |
|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* |
| Mean Sec. | 99.57″ | 222.70″ | 201.15″ | 193.69″ | 327.55″ |
| | (1′39.57″) | (3′42.70″) | (3′21.15″) | (3′13.60″) | (5′27.55″) |
| σ | 67.50″ | 158.00″ | 157.00″ | 173.50″ | 256.00″ |
| σ(Aver.) | 7.84″ | 18.37″ | 18.26″ | 20.17″ | 29.77″ |

(B) *Punch Board Maze*

| | *Method* | | | | |
|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* |
| Mean Sec. | 180.13″ | 249.04″ | 260.05″ | 250.55″ | 339.95″ |
| | (3′.13″) | (4′9.04″) | (4′20.05″) | (4′10.55″) | (6′9.95″) |
| σ | 123.50″ | 136.50″ | 157.00″ | 212.50″ | 243.50″ |
| σ(Aver.) | 14.27″ | 15.08″ | 18.13″ | 24.54″ | 28.12″ |

Correcting the errors as they occurred (Method IV), going back one step (Method II), and not correcting the errors (Method III) were the next fastest methods after Method I. There was very little difference between these three methods in average time. Method V —repeating the error—was the slowest method as well as the most inaccurate. The methods have the same relative rank as to total time scores in the Punch Board Maze as in the Peterson Rational Learning Test.

The differences are all statistically reliable when the first method is compared with the others. Table XIII indicates this.

The process of going back one step and also that of not correcting the error (Method II and Method III) took about two minutes longer than Method I, while Method IV made the learning a minute and a half longer and Method V over three minutes longer than Method I. Method V is also almost reliably longer than Method II, Method III and Method IV.

In the Punch Board, Method I was a minute faster than Method II and Method III. Method I was reliably faster than Method IV and Method V by one minute and three minutes respectively. The only other significant or nearly significant difference in Punch Board Maze Learning is that between the slower Method V and Method II on the one hand, and Method III on the other hand.

Perhaps too much importance should not be attached to the time scores, since they are a measure not only of the subject's reaction time but also of the experimenter's. This is especially true of the Peterson Rational Learning Test, as Roslow has shown that the time for completing this test is partly a function of the Experimenter's speed of reaction (48). Although the time differences between

TABLE XIII

RELIABILITY OF THE DIFFERENCE IN MEAN TIME SCORES FOR THE FIVE METHODS OF LEARNING

(A) *Peterson Rational Learning Test*

| *Methods Compared* | $\frac{D^*}{\sigma D}$ | *Critical Ratio* | *Significance of Difference* |
|---|---|---|---|
| 1 and 2 | $\frac{123.17''}{17.62}$ | 6.99 | (Significant) |
| 1 and 3 | $\frac{101.62''}{18.43}$ | 5.51 | (Significant) |
| 1 and 4 | $\frac{94.16''}{18.14}$ | 5.19 | (Significant) |
| 1 and 5 | $\frac{228.02''}{28.17}$ | 8.09 | (Significant) |
| 2 and 3 | $\frac{21.55''}{20.23}$ | 1.07 | (85 chances in 100) |
| 2 and 4 | $\frac{29.01''}{23.78}$ | 1.22 | (88 chances in 100) |
| 2 and 5 | $\frac{104.85''}{34.45}$ | 3.04 | (Significant) |
| 3 and 4 | $\frac{7.46''}{20.40}$ | .37 | (64 chances in 100) |
| 3 and 5 | $\frac{126.40''}{34.77}$ | 3.64 | (Significant) |
| 4 and 5 | $\frac{133.86''}{28.22}$ | 4.74 | (Significant) |

* $D/\sigma D$ is in terms of seconds.

(B) *Punch Board Learning Test*

| *Methods Compared* | $\frac{D^*}{\sigma D}$ | *Critical Ratio* | *Significance of Difference* |
|---|---|---|---|
| 1 and 2 | $\frac{68.91''}{18.10}$ | 3.81 | (Significant) |
| 1 and 3 | $\frac{79.92''}{25.72}$ | 3.11 | (Significant) |
| 1 and 4 | $\frac{70.42''}{23.68}$ | 2.97 | (Significant) |
| 1 and 5 | $\frac{63.37''}{31.28}$ | 2.04 | (98 chances in 100) |
| 2 and 3 | $\frac{11.01''}{22.27}$ | .49 | (67 chances in 100) |
| 2 and 4 | $\frac{1.51''}{24.04}$ | .06 | (52 chances in 100) |
| 2 and 5 | $\frac{90.91''}{29.99}$ | 3.03 | (Significant) |
| 3 and 4 | $\frac{9.50''}{28.08}$ | .34 | (62 chances in 100) |
| 3 and 5 | $\frac{79.90''}{32.06}$ | 2.49 | (99.4 chances in 100) |
| 4 and 5 | $\frac{89.40''}{38.41}$ | 2.32 | (98.9 chances in 100) |

* $D/\sigma D$ is in terms of seconds.

Method I and the other four methods are statistically significant, yet they are not very significant psychologically. A difference of one or two minutes is not very large in the learning of a task.

On the whole, these time differences fit in with what one might expect. The processes of repeating, also of correcting the error in each trial, inevitably take more time, especially as the subjects had to be told again and again to "Repeat the error." The time for this admonition, which was necessary during the first few trials is included in the total time score. Method I should be the fastest, perhaps partly because the subjects did not have to take time out to correct an error and partly because they actually did learn it in less time. The superiority of Method I in speed is interesting in view of the fact that Holmes (19) found no difference in time between the whole method and the interrupted method and Scott (50) found a time difference between what he called the one-error method and the whole method only with medium sized maze.

### 6. *Retention*

Because of unavoidable absences and school holidays the range of the retention interval between learning and relearning had to be enlarged from an even fourteen days as originally planned to include an interval of from eleven days to seventeen days. This, of course, lessens somewhat the significance of the retention scores, although they still give suggestive information. As previously mentioned the subjects were required to relearn the task learned approximately two weeks previously, before starting to learn the new task. The subjects always relearned by the same method by which they learned. This was done to prevent interference which might result if the methods were changed.

The retention of the Peterson Rational Learning Test, as measured by the per cent of errors saved in the relearning session over the original learning period, (Table XIV) was highest for Method V and lowest for the one-error method.

TABLE XIV

PER CENT. ERRORS AND TIME SAVED ON THE RELEARNING SESSION OVER THE LEARNING SESSIONS AFTER AN INTERVAL OF TEN TO SEVENTEEN DAYS

(A) *Peterson Rational Learning Test*

| | *Method* | | | | | |
|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *Average* |
| Errors | 16.54% | 23.24% | 18.59% | 21.71% | 32.67% | 22.55% |
| Time | 24.38% | 20.50% | 19.78% | 35.08% | 36.03% | 27.15% |

(B) *Punch Board Learning Test*

| | *Method* | | | | | |
|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *Average* |
| Errors | 40.27% | 58.56% | 25.69% | 35.46% | 29.61% | 37.92% |
| Time | 23.75% | 49.85% | 25.04% | 32.06% | 31.41% | 32.42% |

The difference in retention with the various methods is not very great in any case, most of the methods showing a retention in errors between seventeen per cent and twenty per cent, except Method V (repeating the error), which has a retention of thirty-three per cent. This greater retention is probably a result of overlearning, for Method V took the most time to learn and the one-error method the least time.

The saving in time in relearning for the Peterson Rational Learning Test, amounting to about one-third, was highest for Method V and for Method IV, where the error was corrected as it occurred. The time retention for the other methods was about the same—about one-fifth. It is doubtful whether the greater retention in method V is as much a matter of memory as it is a result of the additional practice required and of habituation to this somewhat unusual method.

In the Punch Board Maze the saving in errors was greatest for Method II and next highest for Method I. The lowest per cent errors saved in the relearning session was for Method V and Method III. The saving in time was highest for Method II and next highest for Method V and Method IV. It was least for Method I and for Method III. The subjects had some difficulty with Method II, and it may be that the saving in time represents a practice rather than a memory effect. It is hard to account for the large saving in errors for this method.

Another interesting comparison is that beween the retention on the Peterson Rational Learning Test and the Punch Board Maze. Retention, as measured by the mean per cent of errors saved on the relearning session, was higher for the Punch Board than for the Peterson Rational Learning Test. It may be that the Punch Board Maze took longer to learn, so that it was overlearned, or that it was a motor task, which is often remembered better than a verbal task (2).

Retention was originally computed by comparing the relearning scores with the learning scores, the first trial data omitted. Error scores were found to be much larger on the relearning session, partly, perhaps, because the subjects were not "refreshed" in their memory by being allowed to go through the task once by the "normal" method, as they did in the learning sessions. It is of course impossible to compare relearning errors with zero learning scores. Relearning scores, therefore, were always compared with the learning scores including the data on the first trial. Even when this was done, the relearning score in many cases was higher than the learning score. Hence, it appeared as if the interference between the forms increased over the period of two weeks. McGeoch and McKinney (31) found also that susceptibility to retroactive inhibition increased with time, being greater after seven days than after fifteen minutes. Our subjects, when they were asked to recall a particular form of the task by a particular method, probably had a harder time distinguishing between all the forms they had previously used than they had when the form was presented as a new problem. This interference between the forms probably acted to obscure the real differences in retention as much as the varying intervals between the learning and relearning periods did. Hence, too much significance cannot be attached to the results on retention. McGeoch found no difference between the whole and part methods upon retention, where there was a difference in the learning scores; (30) and Holmes discovered that the differences in favor of the one-error method as against the method of correcting the error were not so striking two weeks later (19). Either retention is a different process from learning, or we have not been able to measure it adequately. Probably, more subjects and more tasks are needed before any definite conclusions can be drawn. It may be that the methods cannot be compared as to per cent. saved in relearning unless the amount of time spent on the original learning is the same for all the methods. Ebbinghaus used this measure of retention with one method only and with the same subject (12).

It is interesting to note in Table XV that the per cent of errors saved in the relearning session over those in the learning session decreased from the first relearning session to the second and third (where there was an actual increase in errors) and then rose from the fourth to the fifth session on the Peterson Rational Learning Test. On the Punch Board, the per cent errors saved decreased from the first to the third session and then maintained a steady level to the fifth session. Evidently interference between the forms was at a maximum on the third session. Whether the increase in retention later was due to a practice effect (that is, in learning how not to let one form interfere with remembering another) or to the fact that the later forms were better learned and therefore better remembered cannot be definitely decided from our data.

TABLE XV

INTERFERENCE EFFECTS AS SHOWN BY THE DECREASE IN PER CENT. ERRORS SAVED FROM SESSION TO SESSION IN THE FIVE RELEARNING SESSIONS FOR ALL FIVE METHODS

| *Session* | *Peterson* | *Punch Board* |
|---|---|---|
| | *Per cent. Errors Saved in Relearning Session over the Learning Session* | |
| I | 41.02% | 75.50% |
| II | + 6.92%* | 40.71% |
| III | + 8.27% | 21.11% |
| IV | 23.81% | 24.17% |
| V | 34.74% | 22.93% |

* Increase in errors over original session.

# CHAPTER IV

## FURTHER COMPARISONS OF THE FIVE METHODS

### 1. *Relearning Scores*

Since the retention scores did not yield very adequate comparisons as among the methods, we decided to compare the mean relearning scores for the five methods, Method I had the fewest relearning errors, as shown in Table XVI and its superiority to the other four methods in the Peterson Rational Learning was statistically significant. The methods retained the same general rank as in the learning session as far as errors are concerned. However, Method V came in second along with Method II in the Peterson Rational Learning Test, whereas it had the greatest number of errors in the learning session. This great reduction in errors may indicate that enough practice with this method would make it more efficient.

TABLE XVI

MEAN ERRORS IN RELEARNING BY THE FIVE METHODS

(A) *Peterson Rational Learning Test*

| | *Method* | | | | |
|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* |
| Mean | 7.34 | 12.03 | 23.38 | 13.56 | 12.00 |
| σ | 4.80 | 10.75 | 17.55 | 14.00 | 11.25 |
| σ(Aver.) | .62 | 1.38 | 2.25 | 1.79 | 1.44 |

(B) *Punch Board Maze*

| | *Method* | | | | |
|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* |
| Mean | 9.47 | 11.27 | 21.79 | 15.71 | 21.52 |
| σ | 6.70 | 10.75 | 15.95 | 15.15 | 16.75 |
| σ(Aver.) | .85 | 1.37 | 2.03 | 1.93 | 2.13 |

In the Punch Board Maze the one-error Method I was significantly superior in number of errors to Method III and to Method V. Method V was significantly inferior in relearning errors to Methods II and I. This is the first case where Method I was not significantly superior to all methods. Although Method I was superior to Method II and to Method IV still the critical ratio was not 3. It seems doubtful that practice would reduce the differences, since the relearning scores are not as accurate as the learning scores, for reasons mentioned previously.

As far as the time for relearning the Peterson Rational was concerned, Method I (going back to the beginning) was reliably faster than the other methods. The relative rank in time scores for the relearning sessions was as follows:

1. Method I—Going back to the beginning.
2. Method IV—Correcting the error.
3 and 4. Method II and Method V—Going back one step and repeating the error.
5. Method III—Not correcting the error.

The only other completely reliable difference was between Method III and Method IV, Method IV being faster. All the other

TABLE XVII

RELIABILITY OF THE DIFFERENCES IN MEAN ERROR FOR RELEARNING BETWEEN THE METHEDS

(A) *Peterson Rational Learning Test*

| *Methods Compared* | $\frac{D}{\sigma D}$ | *Critical Ratio* | *Significance of difference* |
|---|---|---|---|
| 1 and 2 | $\frac{4.69}{1.36}$ | 3.45 | (Significant) |
| 1 and 3 | $\frac{16.04}{2.17}$ | 7.39 | (Significant) |
| 1 and 4 | $\frac{6.22}{1.62}$ | 3.84 | (Significant) |
| 1 and 5 | $\frac{4.66}{1.37}$ | 3.40 | (Significant) |
| 2 and 3 | $\frac{11.35}{2.45}$ | 4.63 | (Significant) |
| 2 and 4 | $\frac{1.53}{1.84}$ | .77 | (77 chances in 100) |
| 2 and 5 | $\frac{.03}{1.47}$ | .02 | (50 chances in 100) |
| 3 and 4 | $\frac{9.82}{2.17}$ | 4.53 | (Significant) |
| 3 and 5 | $\frac{11.38}{2.53}$ | 4.50 | (Significant) |
| 4 and 5 | $\frac{1.56}{1.69}$ | .92 | (82 chances in 100) significant) |

(B) *Punch Board Maze*

| *Methods Compared* | $\frac{D}{\sigma D}$ | *Critical Ratio* | *Significance of difference* |
|---|---|---|---|
| 1 and 2 | $\frac{1.80}{1.60}$ | 1.12 | (86 chances in 100) |
| 1 and 3 | $\frac{10.52}{2.14}$ | 4.91 | (Significant) |
| 1 and 4 | $\frac{6.24}{2.19}$ | 2.85 | (99.8 chances in 100) |
| 1 and 5 | $\frac{12.05}{.20}$ | 5.47 | (Significant) |
| 2 and 3 | $\frac{10.52}{2.21}$ | 4.76 | (Significant) |
| 2 and 4 | $\frac{4.44}{1.81}$ | 2.45 | (99.4 chances in 100) |
| 2 and 5 | $\frac{10.23}{2.49}$ | 4.11 | (Significant) |
| 3 and 4 | $\frac{6.08}{2.42}$ | 2.51 | (99.4 chances in 100) |
| 3 and 5 | $\frac{.27}{2.87}$ | .09 | (52 chances in 100) |
| 4 and 5 | $\frac{5.81}{2.10}$ | 2.77 | (99.74 chances in 100) |

## TABLE XVIII

### Mean Time in Seconds for Relearning by the Five Methods after an Interval of Ten to Seventeen Days

(A) *Peterson Rational Learning Test*

| | *Method* | | | | |
|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* |
| Mean | 91.67″<br>(1′32″) | 156.74″<br>(2′37″) | 221.98″<br>(3′42″) | 125.98″<br>(2′6″) | 162.80″<br>(2′43″) |
| σ | 58.00″ | 155.50″ | 162.50″ | 90.50″ | 111.50″ |
| σ(Aver.) | 7.43″ | 19.91″ | 20.81″ | 11.59″ | 14.28″ |

(B) *Punch Board Maze*

| | *Method* | | | | |
|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* |
| Mean | 123.27″<br>(2′3″) | 131.10″<br>(2′11″) | 183.66″<br>(3′4″) | 145.00″<br>(2′25″) | 195.53″<br>(3′16″) |
| σ | 83.50″ | 100.50″ | 112.50″ | 101.50″ | 110.00″ |
| σ(Aver.) | 10.61″ | 12.77″ | 14.29″ | 12.90″ | 13.98″ |

differences approached reliability except that between Method II and Method V. See Table XIX.

In the Punch Board Maze, Method I was reliably faster than Method III and Method V, but only slightly faster than Method II and Method IV.

## 2. *Factors Eliminated by Rotation*

It is possible that the superiority of Method I might have arisen from some marked defect in the rotation scheme which favored Method I at the expense of the other four methods.

Inequality of the forms in difficulty, or inequality of the groups in learning power are factors that ought to be examined.

Tables XX and XXI show the difference in mean number of errors for all the groups and for all the forms.

The groups seemed to differ in variability, the sigma and V being largest for Group IV on the Peterson Rational Learning Test

TABLE XIX

RELIABILITY OF THE DIFFERENCES IN MEAN RELEARNING TIME BETWEEN THE FIVE METHODS

(A) *Peterson Rational Learning Test*

| *Methods Compared* | $\frac{D}{\sigma D}$ *(in seconds)* | *Critical Ratio* | *Significance of Difference* |
|---|---|---|---|
| 1 and 2 | $\frac{65.07}{17.23}$ | 3.78 | (Significant) |
| 1 and 3 | $\frac{130.31}{18.34}$ | 7.11 | (Significant) |
| 1 and 4 | $\frac{34.31}{10.17}$ | 3.37 | (Significant) |
| 1 and 5 | $\frac{71.13}{11.38}$ | 6.25 | (Significant) |
| 2 and 3 | $\frac{65.24}{23.58}$ | 2.76 | (99.74 chances in 100) |
| 2 and 4 | $\frac{30.76}{16.64}$ | 1.85 | (97 chances in 100) |
| 2 and 5 | $\frac{6.06}{17.62}$ | .34 | (64 chances in 100) |
| 3 and 4 | $\frac{96.00}{19.23}$ | 4.99 | (Significant) |
| 3 and 5 | $\frac{59.18}{23.28}$ | 2.54 | (99.4 chances in 100) |
| 4 and 5 | $\frac{36.82}{14.23}$ | 2.59 | (99.5 chances in 100) |

(B) *Punch Board Maze*

| *Compared Methods* | $\frac{D}{\sigma D\text{(in seconds)}}$ | *Critical Ratio* | *Significance of Difference* |
|---|---|---|---|
| 1 and 2 | $\frac{7.83}{12.51}$ | .63 | (73 chances in 100) |
| 1 and 3 | $\frac{60.39}{14.41}$ | 4.19 | (Significant) |
| 1 and 4 | $\frac{21.73}{16.29}$ | 1.33 | (90 chances in 100) |
| 1 and 5 | $\frac{71.13}{16.95}$ | 4.20 | (Significant) |
| 2 and 3 | $\frac{52.56}{18.09}$ | 2.91 | (99.9 chances in 100) |
| 2 and 4 | $\frac{13.90}{14.29}$ | .97 | (83 chances in 100) |
| 2 and 5 | $\frac{64.43}{17.36}$ | 3.77 | (Significant) |
| 3 and 4 | 38.66<br>16.69 | 2.31 | (88.9 chances in 100) |
| 3 and 5 | $\frac{11.87}{19.79}$ | .60 | (73 chances in 100) |
| 4 and 5 | $\frac{50.53}{14.38}$ | 3.51 | (Significant) |

## TABLE XX

### Mean Errors on the Different Forms Used in Experiment

(A) *Peterson Rational Learning Test*

| | | *Form* | | |
|---|---|---|---|---|
| *A* | *B* | *C* | *D* | *E* |
| 8.61 | 22.16 | 18.71 | 16.31 | 23.98 |
| Mean Errors | 17.95 | | | |

(B) *Punch Board Maze*

| | | *Form* | | |
|---|---|---|---|---|
| *A* | *B* | *C* | *D* | *E* |
| 30.35 | 18.39 | 26.80 | 27.52 | 32.15 |
| Mean Errors | 27.04 | | | |

TABLE XXI

MEAN ERRORS INCURRED BY THE FIVE DIFFERENT GROUPS

(A) *Peterson Rational Learning Test*

| | *Group* | | | | |
|---|---|---|---|---|---|
| | *I* | *II* | *III* | *IV* | *V* |
| Mean | 15.70 | 15.13 | 18.49 | 20.13 | 20.91 |
| σ | 15.41 | 12.13 | 17.41 | 23.87 | 12.30 |
| V | 98.15 | 80.07 | 94.16 | 118.58 | 58.82 |
| Mean Errors | 15.70 | | | | |

(B) *Punch Board Maze*

| | *Group* | | | | |
|---|---|---|---|---|---|
| | *I* | *II* | *III* | *IV* | *V* |
| Mean | 22.67 | 23.73 | 28.42 | 33.78 | 25.8 |
| σ | 13.04 | 16.12 | 22.06 | 22.13 | 14.82 |
| V | 57.47 | 59.58 | 77.62 | 66.25 | 66.67 |
| Mean Errors | 27.04 | | | | |

and for Group III on the Punch Board and least for Group V on the Peterson Rational Learning Test and for Group I on the Punch Board Maze. To summarize, Form A was the easiest and Group II the best, while Form E was the hardest and Group V the worst for the Peterson Rational Learning Test. Form B was the easiest and Group I the best, while Form E was the hardest and Group IV the poorest for the Punch Board Maze.

Boys did better than girls on both tasks, as shown in Table XXII.

TABLE XXII

*Sex Differences (Mean Errors)*

| | *Girls* | *Boys* |
|---|---|---|
| Peterson Rational Learning Test | 19.24 | 16.11 |
| Punch Board Maze | 31.81 | 22.11 |

However, there was an equal number of boys and girls in each session, so that sex differences do not favor any particular method or session.

Practice effect should show a general trend toward a decrease of errors from session to session. Table XXIII gives the results for

TABLE XXIII

PRACTICE EFFECTS AS SHOWN BY MEAN ERRORS FOR EACH LEARNING SESSION

| *Session* | *Peterson Rational Learning Test* | *Punch Board Maze* |
|---|---|---|
| 1 | 29.58 | 42.17 |
| 2 | 13.51 | 31.43 |
| 3 | 15.44 | 23.20 |
| 4 | 16.27 | 22.16 |
| 5 | 14.93 | 16.25 |

all the five methods added together and averaged for each of the five sessions. The errors decrease from the first to the second session in the Peterson Rational Learning Test, where they stay at a constant level. In the Punch Board Maze, errors decrease from the first to the last session continually, except for a stationary level at the third and the fourth session. If the mean errors are computed separately for each session, it may be seen whether inequalities

TABLE XXIV

MEAN NUMBER OF ERRORS FOR EACH METHOD PER LEARNING SESSION

(A) *Peterson Rational Learning Test*

| *Method* | *Session* | *Group* | *Form* | *Mean* | σ |
|---|---|---|---|---|---|
| I | 1 | I | A | 3.43 | 3.89 |
| | 2 | IV | C | 8.87 | 10.80 |
| | 3 | II | D | 7.35 | 6.62 |
| | 4 | III | E | 5.40 | 4.16 |
| | 5 | V | B | 9.85 | 6.49 |
| II | 1 | II | B | 26.00 | 13.44 |
| | 2 | I | C | 14.64 | 9.90 |
| | 3 | V | A | 4.92 | 5.57 |
| | 4 | IV | E | 20.60 | 23.54 |
| | 5 | III | D | 14.07 | 14.25 |
| III | 1 | III | C | 34.53 | 24.71 |
| | 2 | II | E | 17.06 | 15.89 |
| | 3 | IV | A | 16.80 | 21.98 |
| | 4 | V | D | 13.85 | 10.41 |
| | 5 | I | B | 17.36 | 11.99 |
| IV | 1 | IV | D | 26.80 | 36.91 |
| | 2 | V | C | 16.00 | 12.71 |
| | 3 | III | B | 27.53 | 33.32 |
| | 4 | I | E | 22.43 | 28.77 |
| | 5 | II | A | 6.41 | 7.31 |
| V | 1 | V | E | 59.92 | 26.32 |
| | 2 | III | A | 10.93 | 10.62 |
| | 3 | I | D | 20.64 | 22.53 |
| | 4 | II | C | 18.82 | 17.41 |
| | 5 | IV | B | 27.60 | 26.13 |

(B) *Punch Board Maze*

| *Method* | *Session* | *Group* | *Form* | *Mean* | σ |
|---|---|---|---|---|---|
| I | 1 | I | A | 25.79 | 15.08 |
| | 2 | IV | C | 18.40 | 19.52 |
| | 3 | II | D | 8.76 | 4.71 |
| | 4 | III | E | 11.43 | 8.47 |
| | 5 | V | B | 15.87 | 14.11 |
| II | 1 | II | B | 23.59 | 14.94 |
| | 2 | I | C | 23.14 | 12.36 |
| | 3 | V | A | 23.87 | 11.57 |
| | 4 | IV | E | 28.47 | 21.44 |
| | 5 | III | D | 13.36 | 9.52 |
| III | 1 | III | C | 48.64 | 34.67 |
| | 2 | II | E | 46.67 | 38.95 |
| | 3 | IV | A | 36.13 | 22.62 |
| | 4 | V | D | 21.93 | 10.83 |
| | 5 | I | B | 13.50 | 9.26 |
| IV | 1 | IV | D | 63.40 | 33.84 |
| | 2 | V | C | 16.53 | 10.49 |
| | 3 | III | B | 17.29 | 15.48 |
| | 4 | I | E | 18.93 | 11.92 |
| | 5 | II | A | 17.41 | 13.43 |
| V | 1 | V | E | 51.27 | 27.10 |
| | 2 | III | A | 51.36 | 42.17 |
| | 3 | I | D | 32.07 | 16.46 |
| | 4 | II | C | 28.29 | 11.59 |
| | 5 | IV | B | 20.60 | 13.24 |

in the forms or in the groups produced a disturbance in the general downward trend. Thus, if the third session for a method shows more errors than the preceding sessions, it may mean that the form given for that session was harder than average or that the group was below average in learning ability. If one session shows fewer errors than the session following, it may mean that the form was easy or the group superior.

Let us examine Table XXIV.

In the Peterson Rational Learning Test:

1. The Form A, the easy form, was accompanied by a drop in errors in four cases out of five (Method I, II, IV, V).
2. Form E the hard form, was accompanied by a rise of errors in only two cases out of five (Method II and V).
3. The Group I, the superior group, showed a drop in errors in three cases out of five (Method II and IV and I).
4. Group V, the inferior group, showed a rise in errors

in two methods out of five. (Method I and Method V).

In the Punch Board Maze:

1. Form B, the easy form, results in a drop in errors in only two of the five methods; Methods III and V.
2. Form E, hard form resulted in a rise in errors in only two of the five methods; Method I, IV.
3. Group I, the superior group, showed a drop in errors only in two cases; Methods III and V.
4. Group V, the inferior group, showed an increase in errors only in two cases. Methods I and II.

Thus, the trend is not consistent. Sometimes an easy form shows a drop in errors and sometimes a rise in errors. The hard form also results in a lessening of errors as much as an increase in them. The trend for the groups is not only inconsistent, but is often the opposite of what one would expect. 1) It seems probable that the differences in the groups and the forms neutralize each other. An unusually hard form and a superior group will counteract any differences in the long run. 2) Although an easy form and a superior group were combined for Method I in the Peterson Rational Learning Test, this was not the case for the Punch Board Maze which showed the same superiority for that method as did the Peterson Rational Learning Test. The hard form and the inferior group were combined for one session on Method V for the Peterson Rational Learning Test, and the fact that it was followed by a drop on the second session following it indicates that this combination was worse than the others. The combination of Group V and Form E on the Punch Board Maze results in only a slight rise in Method II, and the combination of Group I and Form A on Method I did not result in an unusual low level, for it was followed by a drop on the second session. 3) All the methods have the easy form and the hard form at some time in the rotation scheme. As yet we cannot tell whether it is advantageous or disadvantageous to have an easy form or a hard form on the first, second, third, fourth, or fifth session. Hence, we cannot say that one method was favored by having the easy form earlier than another method or a harder form later.

### 3. *Stereotyping of Errors*

It was thought that a comparison of the kinds of errors as well as of the number of errors for each method might be significant. Certainly, the method in which a subject made the same error over and over again can be said to favor stupid learning to a greater degree than a method which led to more variability. One way in which this question could be answered would be to compare the distribution of errors at each letter in the Peterson Rational Learning Test or at each pair of holes in the Punch Board Maze. If there were any tendency to stereotype the errors at one place, it would show up there in an unduly large percentage of errors. However in Table XXVI, in the Peterson Rational Learning Test, all the five methods showed practically no differences in the distribution of errors. There was a general trend toward fewest errors at the ends and most errors at the middle. No method showed any more cumulation of errors at one place than any other method.

Another way to get at perseveration of wrong responses would be to determine how many times the subjects repeated an error on the next succeeding trial. Peterson always computed the number of perseverative errors, which were repetitions of wrong responses for the same letter; and logical errors, which were repetitions of numbers, already used for earlier letters of the series and which "could not, according to the conditions of the experiment, be correct" (40: 138). It was decided that it was not profitable to compare perseverative and non-perseverative errors in our experiment, however, as the method of not correcting the errors, that of starting over again and the method of going back one step would eliminate the making of the same errors at each single trial with a letter. Logical errors did not seem important for comparing the stereotyping of responses.

In an attempt to get at the relative stupidity of the learning under the five methods, the Experimenter counted the number of errors which were repeated immediately on the next trial (see Table XXV). Of course, with Method I, the trials were only partial.

TABLE XXV

PER CENT OF DUPLICATE ERRORS ON THE TWO TESTS
(*Number of Errors Repeated on Succeeding Trial*)

| *Task* | *Method* | | | | |
|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* |
| Peterson Rational Learning Test | 9.71% | 7.31% | 21.71% | 42.05% | 40.59% |
| Punch Board Maze | 10.39% | 46.15% | 44.44% | 45.71% | 41.51% |

However, our interest was in seeing whether the subject, when he had once made an error, would make it again the very next time he came to that same point in the task. It did not matter whether he came to it after he had been through the whole test once or only partially. In Methods IV and V with the Peterson Rational Learning Test (correcting the errors and repeating the errors) the subject would have to keep on giving numbers for a letter until he got the right one. There would be a chance for making the same errors (not counting the deliberate repetition of the error on Method V) several times on one trial. These errors or repetitions of errors were included with the errors repeated from one trial to another. It was felt that this inclusion of repetitions of errors at one trial with the other errors was justified, partly because such cases were not very frequent and partly because such repetitions were a natural concomitant of these two methods, with which we were comparing the other three.

Table XXV shows decisively that Method IV and Method V had the most duplicate errors and Method II and Method I had the fewest on the Peterson Rational Learning Test. Method II had fewer than Method I. On the Punch Board Maze, Method I had by far the fewest and Methods II, III, IV, and V, had about an equal amount of duplicate errors. There was about the same percentage of duplicate errors on Methods I, IV, and V on the two learning tasks. However, there was a much greater percentage of errors on Methods II (going back one step) and Methods III (not correcting the error) in the Punch Board Maze than on the Peterson Rational Learning Test. Evidently these two methods were more difficult on the Punch Board Maze than on the Peterson Rational Learning Test, at least in respect of causing the same error to be repeated. However, the important thing to notice here is that the method of starting over again does lead to more variability; at least from one trial to the next succeeding one, than do the other methods. It is interesting to note that in the Peterson Rational Learning Test, the method of going back one step leads to even fewer duplicate errors than the method of going back to the beginning. However, except for this, a new trial each time an error is made does cause less perseveration of wrong responses.

### 4. *Distribution of Errors*

Still another way of comparing the methods is to determine if the errors are distributed in the same manner over the five letters of the Peterson Rational Learning Test or the ten pairs of holes in the Punch Board Maze. Table XXVI shows that the general dis-

### TABLE XXVI

### Distribution of Errors Over Each Choice of Reactions

### (A) *Peterson Rational Learning Test*

| *Method* | *Errors* | *Letters* | | | | |
|---|---|---|---|---|---|---|
| | | *A* | *B* | *C* | *D* | *E* |
| I | No. | 135 | 100 | 133 | 109 | 38 |
| | % | 26.19 | 19.42 | 25.83 | 21.32 | 7.38 |
| II | No. | 220 | 283 | 355 | 271 | 102 |
| | % | 17.89 | 22.99 | 28.84 | 22.01 | 8.29 |
| III | No. | 183 | 316 | 353 | 346 | 285 |
| | % | 12.33 | 21.31 | 23.80 | 23.33 | 19.21 |
| IV | No. | 130 | 324 | 443 | 402 | 147 |
| | % | 9.00 | 22.34 | 30.64 | 27.80 | 10.17 |
| V | No. | 228 | 410 | 457 | 529 | 342 |
| | % | 11.60 | 20.85 | 23.24 | 26.91 | 17.39 |
| Totals | No. | 896 | 1433 | 1741 | 1657 | 914 |
| | % | 13.49 | 21.58 | 26.22 | 24.95 | 13.76 |

### (B) *Punch Board Maze*

| *Method* | *Errors* | *Pairs of Holes* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* |
| I | No. | 45 | 82 | 118 | 91 | 208 | 174 | 214 | 153 | 73 | 26 |
| | % | 3.80 | 6.93 | 9.97 | 7.60 | 17.48 | 14.70 | 18.08 | 12.92 | 6.17 | 2.11 |
| II | No. | 71 | 117 | 194 | 248 | 257 | 233 | 257 | 179 | 91 | 50 |
| | % | 4.03 | 6.35 | 11.50 | 17.01 | 15.23 | 13.81 | 15.23 | 10.61 | 5.39 | 2.96 |
| III | No. | 78 | 133 | 211 | 258 | 400 | 345 | 402 | 391 | 222 | 91 |
| | % | 3.08 | 5.25 | 8.34 | 10.19 | 15.80 | 13.62 | 15.88 | 15.45 | 8.77 | 3.60 |
| IV | No. | 54 | 134 | 224 | 219 | 309 | 328 | 335 | 222 | 135 | 42 |
| | % | 2.69 | 6.69 | 11.19 | 10.94 | 15.23 | 16.38 | 16.73 | 11.09 | 6.78 | 2.10 |
| V | No. | 106 | 191 | 257 | 317 | 346 | 353 | 441 | 377 | 241 | 98 |
| | % | 3.81 | 7.00 | 9.43 | 11.63 | 12.69 | 12.94 | 16.17 | 13.82 | 8.83 | 3.59 |
| Totals | No. | 354 | 657 | 1004 | 1133 | 1520 | 1433 | 1649 | 1322 | 762 | 307 |
| | % | 3.49 | 6.48 | 9.90 | 11.17 | 14.99 | 14.13 | 16.26 | 13.04 | 7.50 | 3.03 |

tribution of errors for both tasks follows the laws of primacy and recency, and that there is little difference between methods. However, there seems to be a slight tendency for the errors to be greater in number on the first part of the Peterson Rational Learning Test than on the last part when the method is that of going back to the beginning. Peterson found that complete returns after an erroneous choice (which corresponded to our Method I) on his mental maze caused a slightly larger percentage of errors toward the distal end of the maze than is expected on the laws of chance, and he thought that errors were eliminated in the forward direction, contrary to his usual findings (41). However, our Method I seemed to cause just the opposite—that the errors decreased at the goal end. First, the subject had a greater chance of making errors on the first part of the maze, since he was continually thrown back there on making an error. Second, the subject, although he made more errors on the first part of the maze, went over it so many times that he knew each number for each of the earlier letters and therefore could more correctly reduce the number for the final letter. This is overlearning in a sense which would not result with the Punch Board Maze or the Mental Maze used by Peterson. In each of these the number of possible choices for each succeeding letter decreases as the numbers for the earlier letters are correctly guessed. This is true to a less extent for Method II (going back one step) in the Peterson Rational Learning Test. The other methods show a distribution of errors according to the laws of primacy and of recency. Although in Method IV and Method V primacy reduces the errors more than recency, the general average for all the methods shows that recency results in fewer errors than primacy. On the Punch Board Maze recency was slightly more effective in preventing errors in Methods I and II, and the two factors were just about equal in Methods IV, III and V. The general average for the results, however, again show recency to be stronger factor. Usually, in most studies (59) primacy is found to be more important. One reason for this divergence from the majority of the findings may be that our subjects were given five forms to learn and there may have been greater interference between the different forms on the first letter or pair of holes in the Peterson Rational Learning Test and Punch Board Maze respectively, than on the last. By the time the subjects had come to the last choices on the new task, they may have been able to thrust from their minds, the forms they had learned on previous sessions and thus be able to concentrate on the new task or form.

It is interesting to note that the decrease of errors toward the end and the increase of errors toward the middle bear out Warden's findings (59), but not the "goal-gradient" theory of Hull (21) or the theory of regressive elimination of errors advanced by Peterson (41). Peterson thought that errors decreased as the end of the maze was reached on each trial, partly because the subject had more practice on the first part of the maze before he came to the last, and partly because the motivation increased as the goal was neared. In his theory the number of errors on each choice would equal the total amount of errors on all the choices succeeding it. Peterson (41) found that there was a smaller number of errors on the first and the last part of the Rational Learning Test than one would expect on the basis of chance, as he conceives it. He interpreted this as meaning that the first and last members of the series are more readily mastered than are the members between the extremes even though the errors decreased progressively as the goal was neared. However, our results show no regressive elimination of errors except possibly in Method I on the Peterson Learning Test.

Another test of the distribution of errors used by Peterson was to find out which error was the last to disappear for each subject. In our experiment the last error occurred most frequently for the letter D in the Peterson Rational Learning Test and on the eighth pair of holes, with the seventh a close second in the Punch Board Maze. The errors on the first and last choices were eliminated first more often than the errors on the middle part. In general this

TABLE XXVII

NUMBER OF SUBJECTS MAKING THEIR LAST ERROR AT EACH POINT OF CHOICE

(A) *Peterson Rational Learning Test*

| *Method* | *Letters* | | | | | |
|---|---|---|---|---|---|---|
| | *A* | *B* | *C* | *D* | *E* | *O* |
| I | 6 | 6 | 21 | 23 | 12 | 7 |
| II | 12 | 6 | 19 | 20 | 11 | 6 |
| III | 2 | 12 | 18 | 21 | 13 | 8 |
| IV | 5 | 15 | 15 | 23 | 10 | 6 |
| V | 1 | 11 | 23 | 20 | 13 | 6 |
| Total | 26 | 50 | 96 | 108 | 59 | 33 |

(B) *Punch Board Maze*

| *Method* | *Pair of Holes* | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | *1* | *2* | *3* | *4* | *5* | *6* | *7* | *8* | *9* | *10* | *0* |
| I | 2 | 1 | 6 | 3 | 9 | 9 | 13 | 12 | 13 | 6 | 1 |
| II | 0 | 1 | 5 | 8 | 13 | 17 | 11 | 11 | 5 | 3 | 0 |
| III | 0 | 2 | 5 | 3 | 12 | 14 | 11 | 18 | 8 | 2 | 0 |
| IV | 2 | 2 | 6 | 6 | 15 | 11 | 16 | 11 | 5 | 1 | 0 |
| V | 4 | 3 | 5 | 2 | 7 | 6 | 14 | 19 | 12 | 2 | 1 |
| Total | 6 | 9 | 27 | 22 | 56 | 57 | 65 | 71 | 43 | 14 | 2 |

table agrees with the findings on the total distribution of errors for each choice.

### 5. *Emotional Reactions*

As noted in the beginning of this paper, one does not always prefer to use the method that is the most efficient. When the children were asked which of the methods they preferred, twenty-six out of the seventy preferred to go back to the beginning when they made a mistake. Only those children were used for whom the Experimenter had complete records on both the Punch Board Maze and the Peterson Rational Learning Test. As shown in Table XXVIII, the next most popular method was that of correcting errors as they are made. Not correcting the errors came third, going back one step was fourth, and repeating the error was the least popular.

TABLE XXVIII

PERCENTAGE OF SUBJECTS INDICATING THEIR FIRST, SECOND, THIRD, FOURTH, AND FIFTH PREFERENCE FOR THE FIVE METHODS (PETERSON RATIONAL LEARNING TEST AND PUNCH BOARD MAZE WERE COMBINED)

| *Method* | *Preference* | | | | |
|---|---|---|---|---|---|
| | *1st* | *2nd* | *3rd* | *4th* | *5th* |
| I | 37.14% | 20.00% | 8.57% | 12.86% | 21.43% |
| II | 8.57% | 24.29% | 35.71% | 24.29% | 7.14% |
| III | 15.71% | 18.57% | 11.43% | 30.00% | 24.29% |
| IV | 30.00% | 21.43% | 30.00% | 11.43% | 7.14% |
| V | 8.57% | 15.71% | 14.29% | 21.43% | 40.00% |

As for the methods least preferred, repeating the error (V) had the greatest percentage of children giving it as last choice. The second greatest percentage named the method of not correcting the errors (III), the third largest percentage specified the method of going back to the beginning (I). The fewest children indicated the method of going back one step and that of correcting the errors as they occurred (II and IV) as their last preferences. Although the first preference was for the most efficient method, it was not overwhelming popular, for it also ranked third on last preferences. The most popular method was Method I. When the Experimenter asked the children for reasons for their first choice the answer usually was they "just liked it best."

### 6. *Comparison of Individual Scores on the Five Methods*

When the methods are ranked in the order of the number of errors occurring under them, it appears that on the Punch Board, almost half of the subjects did their best work by going back to the beginning upon making an error, as shown in Table XXIX and about one-seventh their best work by going back one step. Roughly one-third did their worst work by Method V and almost one-third of the subjects were at their worst when using Method IV.

The per cents were not quite as large for the Peterson Rational Learning Test. A little over one-third of the subjects were most efficient with Method I and a little over one-sixth were most efficient with Method II. Over one-third were at their worst with Method V.

TABLE XXIX

PERCENTAGE OF SUBJECTS DOING THEIR BEST, NEXT BEST, AND WORST ON THE FIVE METHODS

(A) *Peterson Rational Learning Test*

| *Method* | *Ranking* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *1* | *1.5** | *2* | *2.5* | *3* | *3.5* | *4* | *4.5* | *5* |
| I | 36.49% | 6.77% | 29.72% | 5.41% | 10.81% | 1.35% | 8.11% | | 1.35% |
| II | 13.51% | 2.70% | 10.81% | 6.77% | 27.03% | 6.77% | 14.86% | | 17.57% |
| III | 12.16% | 5.41% | 10.81% | 1.35% | 14.86% | 5.41% | 24.32% | 1.35% | 24.32% |
| IV | 12.16% | 6.76% | 20.27% | | 18.92% | 1.35% | 22.97% | 1.35% | 16.22% |
| V | 9.46% | 2.70% | 12.16% | 4.05% | 13.51% | 2.70% | 14.86% | 2.70% | 37.84% |

(B) *Punch Board Maze*

| *Method* | *Ranking* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *1* | *1.5** | *2* | *2.5* | *3* | *3.5* | *4* | *4.5* | *5* |
| I | 42.67% | 4.00% | 26.67% | | 5.33% | 1.33% | 12.00% | | 8.00% |
| II | 16.00% | | 22.67% | 1.33% | 26.67% | | 25.33% | | 8.00% |
| III | 14.67% | | 8.00% | | 28.00% | | 22.67% | 1.33% | 25.33% |
| IV | 14.67% | 5.33% | 28.00% | | 21.33% | | 8.00% | 1.33% | 21.33% |
| V | 6.67% | 1.33% | 8.00% | 1.33% | 14.67% | 1.33% | 29.33% | 2.67% | 34.67% |

* 1.5—where first and second methods were equally efficient.

Although the individual results do show that most individuals profited most by using the Method I, still they are not as clear-cut in favoring this method as the group averages. Not every child will profit best by the method that is most efficient for the group.

## INTERPRETATION OF RESULTS

## CHAPTER V

The fact that a return to the beginning upon making an error gave the best results in this experiment, has both theoretical and practical implications. Theoretically it has bearing on the laws of trial and error learning. Even simple serial learning is such a complicated process that no single factor can be expected to account for it. However, certain factors emerge which seem to explain the superiority of Method I.

1) Our experiment throws some light on the frequency and recency theory of learning. Watson and the Behaviorists (60) held that the response practiced most frequently was the one learned in preference to other responses less frequently practiced; and that the response exercised more recently was also favored over that exercised less recently. Of late this theory has come into disrepute. Thorndike, (56), for one, claimed that mere frequency alone did not favor a response, but that frequency was only a medium through which favoring factors for learning could operate, such as "reward" and "belongingness." Peterson (42) cited his experiment with the mental maze, which showed that learning was possible when there was an unannounced new start after each error, to illustrate the unimportance of recency or frequency factors in learning. Our results with the same method also imply that frequency and recency are not as important for learning as was anticipated. For each error made, there will be one more chance to exercise the correct response with Method IV than with Method I where the error can not be corrected until the next trial. Of course, there is no difference between frequency factors in the two methods if the subject gets the response right on his first choice. Moreover, these differences in the frequency of practice of the right response between the two methods are much greater in the first part of the learning period and tend to disappear in the latter part of the period, when the subject is not making any mistakes. However, all these chances to correct the errors should mount up in an overwhelming advantage for Method IV and against Method I, if the frequency theory of learning held as the exclusive explanation. The law of receny, also, is violated by Method I not only because of the time interval between the making of the error and its cor-

rection but also because the last response on each trial is the incorrect one.

Two possible objections might be raised to the statement of the relative unimportance of frequency and recency in Method I. One is that we cannot be sure that the subject did not rehearse the correct response mentally; that is, review his error while going over the first part of the task. The other difficulty is the fact that the Experimenter's telling the subject that he is wrong automatically shows him that the other hole in the pair of holes in the Punch Board Maze is the right one to punch. This is necessarily true in the case of dual choice, as in the Punch Board Maze, although not so in the Peterson Rational Learning Test where the choice is fivefold. The answer to these difficulties is that overt practice of the response proved to be more efficient than mental practice in our experiment. It will be remembered that Method III was not as effective as Method IV. Hence, any mental practice of the right response that occurred in Method I, especially in the Punch Board Maze, does not help as much as actual practice of the correct response. Of course, mental practice of the right response, or what the subject thinks is the right response, is possible only when the first part of the task becomes so well learned that going over it is almost automatic. Only then would be subject's attention be released over the first part of the task to rehearse the new choice of responses later on.

In Method II, the law of frequency is not at a special disadvantage as in Method I, for the subject does not have to wait for a new trial before he corrects the error. The process of going back one step does not constitute a new trial but simply adds on to the old trial in which the error occurred. The law of recency, however, did seem to be violated, for the subject had to take time to go back one step before he could correct the response. This quite frequently resulted in the subject's forgetting what the correct response should be.

We cannot conclude that frequency and recency are unimportant for serial, rote learning. The superiority of Method IV over Method III shows that practice has considerable effect on learning. When the subjects were not allowed to correct their errors, as in Method III, they learned much less efficiently than when they were allowed to correct their errors and go on. We cannot be sure that the subjects did not mentally practice the correct response in Method III, especially in learning the Punch Board Maze. It seems certain, though, that overt practice of the correct response, as in actually pronouncing the number for a letter in the Peterson Rational Learning Test or actually punching the hole with a pencil in the Punch Board Maze, is more efficient than practice in the imagination. The fact that repetition of the wrong response, as in Method V, causes more inaccurate and slower learning than even in Method III, also argues for the law of frequency. Giving the wrong response again, even when the subject is allowed to correct it afterwards, as in the Peterson Rational Learning Test, is less useful than not being allowed to correct an error. The law of recency is also placed at a disadvantage, for the last response on each trial, at any point where an error has been made, is the wrong one in both Methods III and V, because in Method III, the subject continues without correcting the error, and in Method V he repeats the error. It is probable that the superiority of Method IV over Methods III and V was largely due to the fact that recency and frequency were in its favor.

Our final conclusion is that frequency and recency factors are important for learning, but that they may be offset by other factors even more important. In Method I, it is evidently that of getting a new start—which can probably be broken down into a number of conditions influencing efficiency of learning.

2) Our results in this experiment bear on Peterson's hypothesis of "completeness of response." He states (37):

> "There is a continuous overlapping of responses, some of which are helpful and serve the main response as additional stimuli, the latter leading to a more easy and complete response."

Each response to a letter in the Peterson Rational Learning Test or to a pair of holes in the Punch Board Maze are partial acts which are kept when they help to lead to the consummatory act. To complete an act is the motivation of the subject. This is his reward and goal. Those acts which disrupt this process are discarded. Peterson illustrated this by his experiment on length of cul-de-sac. He found that short cul-de-sacs caused the maze to be learned faster than did long ones (38). He made no comment as to how unannounced new starts following errors in a mental maze touched on the theory of completeness of response. Holmes and Carmichael (19) found that a new start caused more effective learning. They interpreted this as disproving the Peterson theory. They thought that the sending of the subject back to the beginning kept the response from being complete and that in spite of this the subject's learning was at its best. This interpretation is a reasonable one. Yet there is another possible interpretation of this. In Method I, the errors are disrupting, and the subject is kept from completing the whole act, because he has to start over again every time he makes a mistake. These errors are like the longer cul-de-sacs in the maze. They delay the finishing of the act on each trial. It may be that they are eliminated more readily for this reason.

Holmes and Carmichael evidently were calling the process of going through the test on each trial the complete act. The consummatory act might also refer to the last two successive errorless trials, which were the final goal of the learning task. Although Method I disrupts each trial, still it leads to the complete act more quickly than the other methods, because the errors are more readily eliminated. In the other methods, the errors do not delay the subject in reaching the last letter or pair of holes in each trial, except for the time taken to correct them, to repeat them, or to go back one step. In Method III the subjects reach the goal the fastest of all, since they do not have to take time to correct their errors, repeat their errors, or go back one step, as in the other methods. It may be that, because the errors do not delay the subject from finishing the task on each trial on these four methods, the errors are not eliminated as fast as in the Method I, where each error carries with it the penalty of not being able to get to the goal on that trial. As a result, the final complete act is not reached as soon in Methods II, III, IV, and V, as in Method I. In any case, the theory of completeness of response is more of a description than an explanation of the efficiency of the five methods.

3) The emotional set produced by a method may also account in part for the difference between the relative efficiencies of the five methods. Method V probably produced confusion and even blocking. The introspections of the subjects showed that it was the most unpopular method of all. The fewest subjects named it as their first preference and the greatest number of subjects as their last choice. In this method Dunlap intended to have his subjects use the method voluntarily. However, it is difficult to get children to repeat a mistake voluntarily. The whole educational system has taught them that errors are to be avoided, not repeated. Moreover, Dunlap did not use his method with serial material. He confined it to the breaking of a single motor habit already formed. Our serial tests gave a chance for the unpleasantness associated with the repetition of the error to spread to the correct responses farther

along in the series; for Thorndike (56) has shown that punishment for an incorrect response spreads to other responses near-by and exerts an inhibiting effect on the learning of the correct responses.

4) It may be that the two rote tasks were organized into a mnenomic scheme and that an error was disrupting unless the subject could get back to the beginning, which might account for the efficiency of Method I. Lumley (29) found that there was much grouping of responses in a multiple choice maze. The proper letters had not only to be learned as such, but they also had to be put in their proper order. The series was organized by the subject into a whole and also into sub-wholes, the easier parts being organized into these sub-wholes before the hard parts.

The responses to the Punch Board Maze or the Peterson Rational Learning Test in our experiment were probably grouped in relation to some mnemonic system, such as 1–10 for the former, or 1–5 for the latter. It is possible that the whole task was divided by the learners into sub-units, like the first part, the middle part and the last part, on the basis of relative ease of learning. If there is this grouping of units, then an error would tend to disorient the subject. If he is allowed to start over according to Method I, he could find his way again, especially in his mnemonic scheme. If he could not begin over, he would have to get back into the scheme as best he could.

Repeating the error (Method V) or not correcting the error (Method III) would not help the subject get oriented after he had made a mistake. Method IV (correcting the error) would probably assist in the orientation of the subject more than Method III or Method V. This theory would account in part for the relative ranks of all the methods in efficiency of learning. It is interesting at this point to compare our results with Carr and Watson's (4). They placed rats in a maze, which they previously learned, to test methods of orientation. They found that the rats almost always went back to the beginning before going on.

5) The fact that there are a smaller number of duplicate errors on Method I, as well as a smaller number of total errors, indicates that a new start causes greater variability. It may be that the small time interval involved in going back to the beginning is sufficient to get the subject to change his mental set for making that particular error. However, the time is too short to involve forgetting the error, for Lashley's experiment on spaced learning and reduction of duplicate errors involved distribution of learning in twenty-four hour

periods. A better explanation is that a new start with each error emphasized the error.

6) Method I, like the part methods, does not allow the subject to proceed beyond the place where he makes errors. In this way the subject tries learning material only as far as he can handle it and goes back when he makes an error. It is like the progressive part method of Pechstein in that it makes the subject tie up what he is learning with the first item of the task. As mentioned before in the progressive part method the subject learns part I, part II, and then connects part I and part II, etc. The advantage of our Method I may be the same as that of the progressive part method which Pechstein found superior—probably that of short economical units together with the advantage of tying up later parts with the beginning.

The following possible explanations of the superiority of Method I, discussed in the preceding pages, have been discarded. 1) Overlearning, because the tests were learned in the shortest time by Method I. 2) Frequency and recency, since the right responses were practiced less frequently and less recently in Method I than in the other methods. 3) Spacing of the learning or the opportunity to forget the error in the time interval involved in returning to the beginning, since the time interval was too short.

The following explanations have been tentatively advanced as factors to account for the greater effectiveness of Method I. 1) Method I does not allow the subject to proceed any farther than he can without error, so that he is always handling the material in the length of task most economical to him at each trial. 2) A new start helps the subject to find his place again. 3) It gives him confidence by his returning to familiar ground at the start of the task, when the learning has been disrupted by an error. 4) The subject's attention is focused upon the error, partly because: a) his motivation to remove the error is increased, since it prevents his getting to the goal or the end of the task, and partly because b) the error is the last item in each trial, and as such acquired the outstanding quality that most final items as well as initial items have when they form the boundary for any task.

Although it may very well be that all four factors are inextricably interwoven in making Method I more efficient, still the best explanation is probably that listed under 2) and 3) in the paragraph above. This explanation presupposes organization of the rote material by the subject into some sort of a scheme in order to learn the acts in serial form. In this system, each letter-number pair in the Peterson Rational Learning Test serves as the stimulus for the next letter-number pair—and similarly for the Punch Board Maze. Therefore, when an error occurs, it breaks up the learner's scheme in which each item serves as a definite landmark. The most efficient way, then, is to start over again rather than to correct the error and go on.

The proceeding pages have been devoted to discussion of the theoretical significance of our experiment. Our findings also have practical significance for ordinary school learning. With the lowering of the standards of the school, especially in recent times of unemployment, to include as many children as possible, there are now many students of lower than average ability. It is then doubly important to find and to apply the most efficient methods of learning. If these children can be taught an efficient way to learn, they can be helped to that extent. Moreover, much of the material learned in grammar school is still of a serial rote nature, to which this method could be applied. This suggestion of the application of Method I to school subjects must be qualified by the statement that 1) the tasks in this experiment are shorter than most school tasks and 2) that the results hold more clearly for immediate learning than for retention. The inferiority of Method V for school work must be considered also in light of the differences between our application of the method and Dunlap's application, mentioned previously.

Further experimentation needs to be done on this subject to test all five methods: a) with longer tasks, b) with adults, c) under conditions where retention can be more adequately tested, d) with a new application of Method V, where the subject repeats the error voluntarily, as Dunlap intended; e) with further experimentation to indicate which of the various factors account for the superiority of Method I.

# CHAPTER VI

## SUMMARY AND CONCLUSIONS

An experiment was designed to compare five methods of learning serial rote material by trial and error. The materials consisted of a five letter form of the Peterson Rational Learning Test where numbers from 1 to 5 had to be associated with letters A to E, and a Punch Board Maze made up of ten pairs of holes in which the subject had to learn which hole in each pair to punch. There were seventy-five children serving as subjects, divided into five groups. Five forms of each task were made up, so that a five-fold system of rotation could be set up. Each group learned the material by all the five methods with a different form for each method. In this way individual differences were eliminated, as each individual's score was compared with his own on the five methods. Not more than one group ever had the same form with the same method, so that differences in the forms were distributed equally among the methods. There were five learning sessions for the five groups. No two methods ever came at the same learning session. This equalized practice effects for the five methods. An attempt was made to control interference effects between preceding and following forms and methods by not permitting any method or form to follow or precede the same method or form as in another group, though this could not be perfectly carried out.

The subjects came for five learning sessions separated by two weeks interval. Beginning with the second learning session, they were tested for retention from the preceding two weeks before they were given the new task to learn. They learned both the Peterson Rational Learning Test and the Punch Board Maze by the same method, at one sitting, only the order between the two tests was counterbalanced during the five sessions.

The results are as follows:

1. When the methods are ranked in order from the one with the least errors to the one with the most errors, they stand in the following rank: Method I (going back to the beginning), Method II (going back one step), Method IV (correcting the error), Method III (not correcting the error), and Method V (repeating the error). This relative rank is maintained on both the Peterson Rational Learning Test and the Punch Board Maze. Moreover, the differences in aver-

age errors between Method I and the other four methods are all statistically reliable.

2. The most accurate method was also the fastest, and the most inaccurate method was the slowest in both the Peterson Rational Learning Test and the Punch Board Maze. The other three methods, correcting the error, not correcting the error, and going back one step, were all about the same in time scores, although slower than Method I, and faster than Method V.

3. Method III (not correcting the error) had the least variability, in the Peterson Rational Learning Test, and Method V had the least in the Punch Board Maze. The greatest variability was in Method IV (correcting the error and going on) and the greatest variability was in Method I (going back to the beginning) in the Punch Board. The variabilities were all very high, both from subject to subject in individual sessions of one group with one method, and from subject to subject in all five groups with one method. The latter was higher because of the variation introduced by the factor of rotation, as well as by the chance variation brought in by the shortness of the task.

4. There was little difference between the methods as far as retention as measured after an interval of ten to seventeen days. On the Peterson Rational Learning Test Method V had the best retention as measured both by per cent of errors and time saved on the relearning period. Method IV had almost as great saving in time as Method V. On the Punch Board Maze Method II (going back one step) had the best retention in errors. Method I had the next best. Method II and IV had the greatest saving of time scores. On the whole, saving in time and error was greater for the Punch Board Maze than for the Peterson Rational Learning Test.

5. When the relearning error scores were averaged, the methods assumed the same relative ranks as before, except that in the Peterson Rational Learning Test Method V was no longer the most inaccurate. Method III and Method IV had the most errors. In the time scores, Method I was still the fastest in both tests. However, in the Punch Board Maze, Method V and Method III were tied as the slowest. In the Peterson Rational Learning Test, Method III was the slowest.

6. Although the forms and the groups used in the rotation scheme were not equal as far as errors are concerned, they did not consistently favor any method at the expense of another. Boys did

better than girls on both tasks, but since there was an equal number of sexes, this sex difference did not favor any method.

7. Method I had the fewest or second stereotyped responses, *i.e.*, the fewest duplicate errors, as well as the fewest total errors in both the Peterson Rational Learning Test and the Punch Board Maze.

8. There was no difference between the groups as to distribution of errors over the two tests, except that in Method I on the Peterson Rational Learning Test there was a larger per cent of errors on the first letter and a smaller per cent on the last letter than in the other methods. On the whole, the errors were distributed according to the laws of primacy and recency with fewer errors at the end than at the beginning, and the most at the middle rather than according to the theory of good gradient with a decrease of errors as the goal is approached. Errors at the middle parts were the last to disappear, while those at the first and at the last parts were the first to disappear.

9. Most of the children listed Method I as their first choice and Method V as their last.

10. Somewhat less than one-half the children did their best work by Method I, when each child's score on the five methods was compared individually rather than in group averages. One-third did their worst work on the Method V.

11. An interesting incidental result is that with the easier task, the Peterson Rational Learning Test, the number of errors decreases from the first session for all the methods to the second session, where it stays at the level for the rest of the learning periods. In the Punch Board Maze, the errors decrease steadily from the first session to the last session. In the retention results, the interference between the different forms of the two tasks increases from the first session to the second and to the third where it is at a maximum and then decreases, although never reaching the level of the first session.

12. Another interesting incidental result is that with the easier task, the Peterson Rational Learning Test, the number of errors decreases from the first session for all the methods to the second session, where it stays at about this level for the rest of the learning periods. In the Punch Board Maze, the errors decrease steadily from the first session to the last session. In the retention results, the interference between the different forms of the two tasks increases from the first session to the second and to the third where it is at a maximum and then decreases, although never reaching the level of the first session.

13. The split half reliability of the Peterson Rational Learning Test average +.72 and for the Punch Board Maze +.83, while the relearning correlations were +.27 for the Peterson Rational Learning Test and +.22 for the Punch Board Maze.

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